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PALAEOPATHOLOGY OF A CALIFORNIA ARCHAEOLOGICAL SITE *

JAMES G. RONEY, JR.

Introduction

Palaeopathology is the study of disease as it occurred in past populations. Klebs justified this subject or discipline because disease is important in the history of man and palaeopathology proposed to shed some light on the history of diseases. (9) The term was adopted by Ruffer in the early twentieth century. Pales has outlined the historical development of palaeopathology as having three main periods: (13)

1774-1870: Palaeopathology of quaternary fauna.

*This study was completed in 1950 but was not published at that time because of the absence of archaeological data with which to make it more meaningful. Recently Dr. Arnold R. Pilling, now at Wayne State University (Detroit), has been kind enough to prepare a brief summary of the archaeological findings gleaned from various published and unpublished papers and his own experience as Assistant Archaeologist for the University of California Archaeologic Survey in the excavation of the site Sonoma-299 in 1949. The section on archaeology including the references is the work of Dr. Pilling.

Henry P. Brean, M. D., Chief of Radiology, Herrick Memorial Hospital, Berkeley, arranged for radiography of selected specimens. His cooperation, interest, and suggestions are gratefully acknowledged.

Further acknowledgments go to Professor Theodore D. McCown, Department of Anthropology, University of California, for his guidance in the study, to Professor E. W. Gifford, then Director of the Museum of Anthropology, University of California, for permitting access to the material for study, and to Mr. Franklin Fenenga, then archaeologist for the University of California Archaeologic Survey, who invited the author to make this study in 1949.

1870-1900: The beginnings of human palaeopathology with emphasis upon traumatic lesions and syphilis. During this period much time and energy was devoted to arguments resulting from confusion of normal morphology of different races or species with pathological characteristics.

1900-1930: The study of infectious diseases, of evidence of prehistoric medical and surgical practices, of pathological conditions in animals of first geologic eras, and the use of laboratory methods in making investigations.

A fourth period beginning in 1930 might be called the period of palaeoepidemiology, marked by the work of Hooton on *The Indians of Pecos Pueblo.* (8) This period is characterized by the study of evidences of disease in samples of populations, using statistical compilations to determine prevalence. Krogman noted the occurrence of different pathological findings in different age, sex, and racial groups in his study of Tepe Hissar in Iran. (10) Angel in his study of skeletal material of ancient Greece noted the change in different lesions from the Neolithic, through Early Iron Age, to Classic-Byzantine times. (1) Sex differences in disease occurrences also were tabulated. Goldstein has utilized this same approach in studies of pathological conditions in skeletal material from archaeological sites in Texas. (4) (5) Vallois has studied life expectancy changes from lower palaeolithic, through upper palaeolithic, to mesolithic times. (20) Todd made a similar study of later populations. (19) Thus, in this fourth period of development of palaeopathology, there is emphasis upon studying a population sample, upon relating disease to age, sex, and race, upon observing temporal trends in disease, and upon relating disease to cultural factors. This approach is, therefore, epidemiological, concerning itself with host and environmental factors in diseases occurring in a population sample. This contrasts with previous approaches where individual pathologic bones were reported upon without reference to the total individual, to the culture, or the rest of the population. Also, in earlier periods, there was greater emphasis upon philosophical questions of the place of disease in the evolution and extinction of races and upon questions of the origin of disease.

Methodology

The present paper limits itself to the human palaeopathology of a single California archaeological site. In order to clarify the approach used here, a methodology of palaeopathology is presented, even though not all of the techniques could be utilized. This methodology is proposed for the study

of pathological conditions in skeletal material from archaeological sites. It assumes that the site in question has been excavated according to best archaeological techniques with recovery of all artifacts and skeletal material, their proper preservation, and their spatial location within the site. This being granted, the following methodology is proposed:

A. Archaeological investigation:
   1. Reconstruction of the culture on the basis of artifacts recovered, geographic location of site, relation to other sites, and the date or dates of the site.
   2. Examination of art forms depicting disease conditions.
   3. Investigation of artifacts used in medical or surgical practice.
   4. Association of artifacts, levels, and other conditions with the individual skeletons found.

B. Study of skeletal remains:
   1. Study of the total individual: Careful examination of skeletal material, bone by bone, to determine evidence of gross pathological conditions.
   2. Determination of age of the individual at death.
   3. Determination of sex of the individual.
   4. Use of special techniques for further investigation of pathological conditions, such as roentgenology, histopathology, microbiology, and serology. Roentgenology has been used by Moodie in the study of mummified remains. (12) Histopathology has been utilized by Ruffer on Egyptian mummies and by Michaelis on skeletal material. (16) (11) Serologic studies of extractions from cancellous bone and microbiologic studies of preserved tissue may offer sources of information for palaeopathology.
   5. Diagnosis: On the basis of type and occurrence of lesions in different sites in the skeleton, the association of one type of lesion with another, the distribution of lesions according to age and sex, their distribution in time if the site is stratified, and of cultural and environmental data, some attempt at diagnosis is made.

C. Statistical analysis:
   1. Determination of prevalence of different deduced diseases.
   2. Determination of mortality figures noting range of age at death and mortality peaks at different ages.

Archaeology

The midden designated as Son-299 is situated on the west coast of the peninsula known as Bodega Head and adjacent to land-locked Bodega Harbor, about 45 miles north of the Golden Gate, near the southern boundary of Sonoma County. The open coast is three-fourths of a mile away across Bodega Head. The eastern edge of the site was formerly washed by tidal wavelets from the bay.

Site Son-299 has been known to archaeologists since it was located by Jesse Peter in his survey of the Sonoma coast in 1938. (14) Private collectors have excavated along the eastern edge of Son-299 for over twenty years. Two of these amateurs published a note concerning the site in 1933. (15) Another excavator has given his specimens from the site to an eastern university. Still another collection from this midden was recovered by Mr. Hardie Chenowith who, in 1948, brought the attention of University of California archaeologists to this locality. A trench 25 feet wide was excavated through the site by the University of California Archaeological Survey during the summer of 1949. A large series of skeletons and a considerable assemblage of artifacts were recovered during this excavation.

Aboriginal artifacts from the site are from that cultural period known as the Central California Middle Horizon. These specimens are most like those from the areal sub-division of the Middle Horizon known by the term "McClure Facies." (2) Although charcoal samples from Son-299 have not been submitted to laboratories for a determination of the date when the site was occupied, a Middle Horizon site on the eastern shores of San Francisco Bay has produced a radiocarbon date of 385 B. C. ± 150 years. (3) (7) We may assume, therefore, that Indians were living on site Son-299 between two and three thousand years ago.

The inhabitants of Son-299 probably derived most of their food from the adjacent mud-flats of Bodega Harbor; the midden was composed in large part of several species of shallow-water shell-fish, primarily clams and mussels. (6) These people also ate fish, for caches of net-sinkers and pockets of fish bone occurred throughout the site. Birds, sea otter, seal, and deer were likewise consumed. We may conclude that these natives ate few acorns or other seeds which required milling, because utensils for grinding were not common. The burned appearance of much of the bone and shell suggests that cooking was done in the coals of fires.

PATHOLOGY

The skeletal material from Son-299, now in the Museum of Anthropology, University of California, Numbers 12-7960 through 12-8000, consisted of forty-four individuals in very fragmentary condition. These included six infants (under one year), 11 children (1-20 years), and 27 adults (20 years or over). (See Table I)

TABLE I

DISTRIBUTION OF PATHOLOGICAL FINDINGS BY AGE AND SEX

	Total No.	Pathological No.	Pathological %
Infants (under 1 year)	6	0	0.0
Children (1-19 years)	111	0	0.0
Adults (20 years or older)	27	20	74.1
Males	17	16	94.1
Females	10	4	40.0

The methodology outlined above was applied where possible, although it could not be utilized completely. The procedure consisted of the following:

1. Gross examination of all bones in each individual and recording of all pathologic manifestations.
2. Determination of age wherever possible, utilizing pubic symphysis stages, tooth eruption and size. (Only in twenty could age be determined because of the large number of crushed and fragmentary skeletons.)
3. Determination of sex utilizing morphologic characteristics of the cranium and pelvis and the general appearance of other portions of the skeleton.
4. Radiographic examination of selected gross lesions.
5. "Diagnosis" of disease processes.
6. Statistical analysis.

In this section, consideration is given first to pathological manifestations and the deduced processes which produced them, and second to the occurrences of these processes in individuals.

A. Pathological processes:

The processes involved in the pathological manifestations of this simple may be classified as inflammatory, traumatic, neoplastic, or congenital. (See Table II)

TABLE II

TYPES OF PATHOLOGICAL CONDITIONS

			Inflammation										
No.	Sex	Age in Years	Arthritis	Periostitis	Alveolar Abscess	Dental Caries	Osteomyelitis	Sinusitis	Miscellaneous	Fracture	Neoplasm	Congenital Anomaly
7962	M			x			x					
7965	M		x	x								
7967	M		x	x	x							
7968	M	45–50	x	x				x				
7969	M	35–39	x	x	x					x	x	x
7976	F	27–30	x	x	x				x[1]			
7979	M	39–44	x		x					x	x	
7980	M?		x		x							
7984	M		x							x		
7988	M		x		x		x		x[2]	x		
7989	M		x	x								
7990	M		x		x							
7991	F		x							x		
7992	F?			x	x							
7993	F		x									
7996A	M?			x		x						
7997	M		x					x				
7998	M		x		x							
7999	M		x		x					x		
8000	M		x									
			17	9	10	1	2	2	2	6	2	1

[1] Bone destruction of greater trochanter of left femur and of right talus.
[2] Vertebral wedging, thickening and prolongation of inferior margin of ribs.

Inflammation:

1. Arthritis:

Arthritis was manifested by proliferation of bone at joint margins, erosion of articular surfaces and eburnation of surfaces. The most commonly involved joints were thoracic and lumber spine, sacro-iliac, and elbow and knee joints.

The distribution of arthritic lesions in the skeleton is indicated below:

Cervical spine	4	Elbow joints	5
Thoracic spine	7	Metacarpal joints	3
Lumbar spine	11	Phalangeal joints of hand	1
Lumbosacral joints	1	Hip joints	1
Sacro-iliac joints	4	Knee joints	7
Costovertebral joints	5	Ankle joints	2
Sternoclavicular joints	1	Metatarsal joints	4
Coracoclavicular joints	1	Phalangeal joints of foot	1
Shoulder joints	2		

In most cases, the involvement of joints was symmetrical. Of the seventeen individuals affected with arthritis, fourteen were males and three were females.

The nature of the lesions, the more common occurrence in males, the more common involvement of the larger, weight-bearing joints, indicates that this is osteoarthritis. In one instance, there was direct relation to trauma, where fracture of the neck of the left radius and Colles' fracture of the right radius were associated with arthritis of the elbow joints. There were no other joints involved in this case.

The frequent occurrence of healed fractures may also attest to the rugged existence of this population and may account for the high prevalence of arthritis, especially in the male.

2. Periostitis:

Nine individuals exhibited disturbances of the surface of bone characterized by plaque-like deposits of bone separate from the bony cortex, porous thickening involving the cortex, and smooth elevations of dense bone. These different lesions may represent different types of periosteal disease or they may represent different stages of the same disease. Seven males and two females showed evidence of this type of abnormality. The tibia and fibula were most frequently affected. The distribution of periostitis in the skeleton is shown below:

Cranium	1	Tibia	7
Clavicle	2	Fibula	5
Radius	1		

The nature of the lesions and their sites of occurrence are suggestive of syphilitic infection.

3. Osteomyelitis:

Two individuals, both males, showed bark-like proliferation on the surface of bone with irregular sinus openings extending into the underlying bony structure. Roentgenograms revealed typical areas of bone destruction in addition to the periosteal reaction. The bones involved in this type of pathological condition were mandible, ulna, femur, and tibia.

The cause may be staphylococcal, streptococcal, pneumococcal, or enteric organism infection. Any one of these would also account for the high infant mortality. The mandibular lesion may have resulted from a dental abscess.

4. Inflammatory processes of special sites:

a. Sinuses: Abnormalities of the maxillary antrum were noted in two individuals where the fragmentary condition allowed visualization of this area. In one, there were irregular, superficial deposits on the lateral wall of the antrum. In the other, there were fistulae from the upper molar sockets to the antra bilaterally. Both individuals were males.

b. Alveolar processes: In ten individuals, openings of varying size occurred in the alveoli at the level of the dental roots. In one individual, a large opening about one centimeter in diameter above the left upper medial incisor communicated with an enlarged incisive canal; a roentgenogram revealed a large space involving the root of the left upper medial incisor tooth. Originally, this may have been a cyst of the incisive canal which subsequently became infected. Alveolar abscess formation may be associated with the dental attrition of this sample. The enamel or even the dentin being worn through to expose the pulp cavity resulted in the spread of infection to the roots and in the formation of abscesses eventually draining through the alveolus.

c. Teeth: Carious teeth were found only in one individual, in contrast to abscessed teeth as mentioned above. Nearly all individuals exhibited moderate to marked dental attrition.

d. Vertebral column: One individual exhibited wedging of three thoracic vertebrae with typical gibbus formation of the spine characteristic of Pott's disease.

e. Ribs: One individual showed thickening and extension of the inferior border of ribs associated with pulmonary infection.

f. Miscellaneous: One individual (female) had an area of bone destruction one centimeter in diameter on the posterior surface of the greater trochanter of the left femur and a small sinus opening onto the trochlear surface of the right talus.

Trauma:

Fractures were indicated by local enlargement, angulation, and shortening of bones. These conditions occurred in six individuals (5 males, 1 female) with a total of fourteen bones involved. The distribution of fractures in the skeleton is listed below:

Neck of radius	1
Distal end of radius, (Colles' fracture)	3
Phalanges of hand	2
Metatarsals	6
Phalanges of foot	2

Neoplasm:

Two males had osteomata, one on the left temporal bone and the other on the frontal bone.

Congenital Anomaly:

One male had two congenital anomalies, a bifid rib and spina bifida of the sacrum up to the second segment.

B. Occurrence of different processes in individuals:

All of the 20 individuals having signs of morbid changes were adults. Table I shows the distribution of pathological conditions in individuals by age and sex. The preponderance of gross pathological lesions was found in the adult male.

The types of pathological manifestations occurring in twenty individuals is shown in Table II. It will be seen that inflammatory processes outnumber the rest, traumatic lesions being second. All but three of the individuals had evidence of more than one pathological process. Table III shows the prevalence of different diseases in twenty adults. Four individuals showed considerable ailment.

Number 7969: This adult male, 35-39 years of age at death, had osteoarthritis of the cervical, thoracic, and lumbar spine, and of the sacroiliac and knee joints. He also suffered from abscessed teeth which drained through the alveolus. In addition he had periostitis of both tibiae on the medial and lateral surfaces, and of the lateral surface of the distal end of the left fibula. Further, he had an osteoma of the squama of the left temporal bone. He exhibited two congenital anomalies, a bifid rib and spina bifida of the sacrum. Also, he had healed fractures of the right fourth and fifth metatarsals.

TABLE III

PREVALENCE OF DIFFERENT DISEASES IN 27 ADULTS

	17 Males		10 Females		27 Total	
	No.	%	No.	%	No.	%
Inflammatory	16	94.1	4	40.0	20	74.1
Arthritis	14	82.3	3	30.0	17	63 0
Periostitis	7	41.2	2	20.0	9	33.3
Alveolar abscess	8	47.1	2	20.0	10	37.0
Dental Caries	1	5.9	0	0.0	1	3.7
Osteomyelitis	2	11.8	0	0.0	2	7.4
Sinusitis	2	11.8	0	0.0	2	7.4
Miscellaneous	1	5.9	1	10.0	2	7.4
Traumatic: Fractures	5	29.4	1	10.0	6	22.2
Neoplasm: Osteoma	2	11.8	0	0.0	2	7.4
Congenital Anomaly	1	5.9	0	0.0	1	3.7
Total	16	94.1	4	40.0	20	74.1

Number 7976: This individual was an adult female, aged 27-30 at time of death. She suffered from alveolar abscesses in the region of the upper and lower molars. She had extensive osteoarthritis of the spinal column, of the sacro-iliac, shoulder, knee, and ankle joints, and of the right thumb and left great toe. She also had periostitis of the right clavicle, left tibia, and the fibulae. Further, there were areas of bone destruction on the greater trochanter of the left femur and on the right talus.

Number 7979: This adult male died at the age of 39-44 years. He suffered from osteoarthritis of the thoracic and lumbar spine, and of the knee and ankle joints. He had alveolar abscesses in the region of the left upper premolars. There was an osteoma on the right side of the frontal squama. Further, he had sustained a right Colles' fracture which had healed with shortening and angulation. Also, there were fractures of the first and second phalanges of the hand which had healed with some angulation.

Number 7988: This adult male had alveolar abscesses and arthritis of the thoracic and lumbar spine, and of the left knee joint and toes. He exhibited three wedged thoracic vertebrae typical of Pott's disease. In addition, he had thickening and irregular prolongation of the inferior

border of ribs associated with tuberculous disease of the chest. Further, he had osteomyelitis of the left femur and both tibiae. He had suffered fractures of the second through fifth left metatarsals which had healed with some deformity. There was fusion of a middle and distal phalanx.

The distribution of age at death can be compared with the mortality figures in 1956 for San Mateo County and the State of California. (17) (18)

	Son-299	*San Mateo County*	*California*
Infants (under 1 year)	13.6%	7.2%	6.7%
Children (1-19 years)	25.0%	2.8%	2.6%
Adults (20 years or over)	61.4%	90.0%	90.7%

The great difference between mortality of infants and children in Sonoma-299 and those in present populations is obvious. Also, the oldest adult in Son-299 whose age could be determined was 45-50 years old. This is in contrast to the large proportion of deaths in California after age 50 years.

Conclusions

1. A large proportion of infants and children in this sample indicates a high infant and child mortality. Since no gross pathologic lesions were detected in this sub-adult group, one may conclude that they died from some acute process, such as infection with respiratory or enteric organisms, or pyogenic organisms such as staphylococci. These might be the same organisms as those producing osteomyelitis in later years.

Another cause of death could be trauma. This could not be ruled out because of the generally fragmentary condition of all the skeletal material.

2. Pathological conditions of some sort were detected grossly in 74.1% of the adults. These were classified as inflammatory, traumatic, neoplastic, or congenital. Inflammatory processes were most common, with trauma the second most frequent cause of disease. None of the pathological conditions found could be associated with cause of death with any certainty.

3. Pathological changes were more than twice as prevalent in males as in females, probably because of the sexual division of labor in the culture.

4. Of the inflammatory lesions, arthritis was most frequent, alveolar abscess next, and periostitis third. Sinusitis and osteomyelitis occurred in two individuals. Dental caries was found in one. A diagnosis of tuberculosis of the spinal column was made in one individual.

5. Fractures which had healed were found in six individuals, five of whom were males. Most of the fractures occurred in the metatarsals, Colles' fractures being second in number. These may be associated with the hunting-fishing-gathering existence where falling or crushing injuries are hazards, especially on slippery rocks of the coastal area.

6. Nearly all adult individuals showed moderate to marked dental attrition. This may be associated with their diet of shell-fish, fish, birds, and mammals, which were cooked in live coals and consequently acquired some grit. There was no evidence of the use of mortars for grinding seeds.

7. There was no skeletal evidence of nutritional deficiency.

8. There was no evidence of death from violence such as might be inferred from embedded weapons. This, of course, does not rule out other modes of violent death. Because of the crushed condition of the skeletal material, no conclusions could be drawn one way or the other.

9. At least one individual seemed to have been afflicted with tuberculosis, and several had lesions suggestive of syphilis.

10. There was no skeletal or archaeological evidence of surgical intervention in the course of disease. There were no artifacts present which could be associated with medical practices.

11. The study of the entire skeleton, the association of pathological conditions with age and sex, the study of such conditions in relation to population and mode of life, and the use of roentgenography, were found to be valuable palaeopathological procedures.

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WHEN MEDICINE WAS IN FLOWER

LYNN THORNDIKE

At no period perhaps or place in recorded history did physicians and professors of medicine have a better opinion of themselves or occupy a higher social position than in Italy and especially at Padua in the fourteenth and fifteenth centuries. I say this despite the much greater accomplishment of modern medicine, and despite the reaction of Renaissance humanistic medicine and of Paracelsus against their scholastic forebears.

Of the false modesty of the great Conciliator, Pietro d'Abano, who in addressing his treatise on poisons to the pope, spoke of himself as *minimus medicorum*,[1] there is an occasional reminiscence, as when Philip Bandini, son of the encyclopedist,[2] calls himself *medicine professor inmeritus*.[3]

But a *Consilium* against leprosy is entitled " by the most famous doctor of arts and medicine, master Bartholomew of Montagnana." [4] Another opens, " Here the most celebrated Montagnana . . ."; [5] a third, " Bartholomeus Montagnana arcium et medicine doctor famosissimus . . ."; [6] a fourth, " Medicine Monarcha Montagnana." [7] Then all these are surpassed by " The most celebrated doctor of arts and medicine and sole monarch in the world of highest thoughts expressed, lord master Bartholomew of Montagnana." [8] This in turn is matched by " Acta per famosissimum et solum in orbe artium atque medicine professorem amplissimum dominum magistrum Bartholemeum de Montagnana," [9] and by " Acta per famosissimum atque celeberrimum artium et medicine doctorem et monarcham dominum magistrum Bartholomeum de Montagnana in floridissimo studio Paduano." [10] Meanwhile we have had " Famosissimus Montagnana " [11] and " Montagnana celeberrimus," [12] and come later to

[1] Oxford, All Souls 75, fol. 33ra.

[2] See the account of the *Fons memorabilium universi* of Dominicus Bandinus in my *History of Magic and Experimental Science*, III, 560-67.

[3] At Munich cod. lat. 28, fol. 2ra.

[4] All Souls 75, fol. 57ra.

[5] *Ibid.*, fol. 92vb.

[6] *Ibid.*, fol. 105rb.

[7] *Ibid.*, fol. 150ra.

[8] *Ibid.*, fol. 188va.

[9] *Ibid.*, fol. 222va.

[10] *Ibid.*, fol. 239va.

[11] *Ibid.*, fol. 236vb; also at fol. 271rb, and 253vb.

[12] *Ibid.*, fol. 237va; also 274rb.

"Most celebrated Montagnana sole monarch in the sphere of arts and medicine." [13]

Less fulsome but still expressed in superlatives are the designations of other physicians in other manuscripts. Christopher de Honestis, born in Florence and deceased at Bologna in 1392, is called "most famous," [14] as is Alexander Sermoneta of the next century.[15] Ugolinus of Monte Catino is "most excellent," [16] while Antonio de Cermisone is both most excellent and most famous.[17] Hugh of Siena is termed "most subtle." [18]

The copyists of manuscripts did not always apply flattering epithets to the authors of recent medical works. When Leonard de Montilio, while studying medicine, transcribed the commentary of Marsilius de Sancta Sophia (died 1405) on the first Fen of the fourth book of the *Canon* of Avicenna, he described it merely as "Recepte edite . . . a magistro Marsilio." [19] Similarly Donato of Chiugi, when he transcribed the Question on the elements of Marsilio in 1396, called him merely "master Marsilius de Sancta Sophia." [20] But he had earlier called him "most venerable," when copying his *Questio de multiplicatione specierum* in 1391.[21] A copy of his Questions on *De generatione et corruptione*, which was made in 1407, referred to him as *honorabilem*,[22] while in another manuscript of the commentary on Avicenna he is called distinguished and famous.[23] In a "Consilium ordinatum per physicos et

[13] *Ibid.*, fol. 244rb.

[14] Munich cod. lat. 708, fol. 104vb: "Explicit expositio utilis super Antidotario Mesue a famosissimo artium et medicine doctore magistro Christoforo de Giorgiis de Florencia."

[15] Munich cod lat. 441, fol. 90(14)r: "Consilium doctoris famosissimi medicine Alexandri Sermonete."

[16] Paris, Bibl. Nat. latin 6910, fol. 142rb, "Consilium excellentissimi artium et medicine doctoris magistri Ugolini de monte katino . . ."

[17] Oxford, Bodleian, Laud. Misc. 617, fol. 190rb: "Et in hoc terminantur utiliora consilia excellentissimi ac famosissimi artium et medicine doctoris magistri Antonii Cermisone ad laudem omnipotentis dei eiusque virginis et matris Marie totiusque curie celestis triumphantis, Amen."

[18] Venice, S. Marco VI, 72 (Valentinelli XII, 20), fols. 153rb-155ra, "Questio Bononie disputata compendioseque recitata per subtillissimum artium et medicine doctorem Ugonem Senensem."

[19] Vendôme 244, 15th century, 111 fols.

[20] Oxford, Bodleian, Canon. misc. 177, fol. 5v.

[21] *Ibid.*, fol. 42r.

[22] Munich, cod. lat. 26929, fol. 193rb.

[23] Wiesbaden 61, 15th century, fol. 121ra-124vb (incomplete): "Incipiunt recepte super primam fen quarti canonis Avicenne date ab eximio et famoso doctore in medicina magistro Marsilio de Sancta Sophia de Padua." Similarly Erfurt, Amplon. F. 253, 13-14th century, fol. 159r: "Inc. recepte verificate et ordinate per eximium et excellentissimum artium et medicine monarcham mag. Marsilium de Sancta Sophia . . ."

viros preclaros," he is grouped under that designation with Iohannes de Borsano, Pietro da Tossignano, Usbertus de Cremona, and others.[24]

In a single manuscript at Munich Bartholomew of Vagana (Varignana?) is called most excellent;[25] John of Parma, a distinguished doctor;[26] Gentile da Foligno, most excellent doctor of arts and medicine, and "illuminator of all medicine";[27] Gentile and Fabiano, distinguished;[28] and William of Brescia, a most excellent physician and most pious archdeacon and canon.[29] There also are "commonly received conclusions put forth by men of worth and especially by master Nicolaus of Sancta Sophia, father of master John of Sancta Sophia,"[30] and an anonymous "treatise of simple medicines of famous masters."[31]

Galeazzo of Sancta Sophia is called *clarissimi doctoris* in the rubric preceding his work on Simples in another manuscript,[32] but in a third he receives no complimentary epithet.[33] John of Sancta Sophia is called a most excellent master in a manuscript of his *Consilia*.[34]

If some of these designations seem somewhat stereotyped and *pro forma*, let us turn to those in manuscripts of the treatise on intension and remission of forms by James of Forlì. In one he is called "most excellent and most famous doctor of arts and medicine."[35] But in a second he is "the most severe monarch of arts and medicine,"[36] while two others proclaim him "one-time monarch and mirror of the whole world, doctor of arts and medicine, who by his divine genius composed it in the clarity of his age, when only twenty-one."[37]

[24] Paris, Bibl. Nat. latin 6910, fol. 129vb.

[25] Cod. lat. 23912, fol. 254va, "ad postulationem imperatoris Henrici."

[26] *Ibid.*, fol. 258rb: "Finitur hic tractatus farmacorum eximii doctoris magistri Iohannis de Parma 1426 feria 5a ante festum sancte Crucis exaltationis Wyenne."

[27] *Ibid.*, fol. 1ra: "Incipiunt recepte excellentissimi artium et medicine doctoris Gentilis de Fulgineo illuminatoris totius medicinae."

[28] *Ibid.*, fol. 43ra.

[29] *Ibid.*, fol. 247va, "complete 1394 in VIa corporis Christi Padue."

[30] *Ibid.*, fol. 173rb.

[31] *Ibid.*, fol. 258rb.

[32] Munich, cod. lat. 252, fol. 3r.

[33] And his name is misspelled: British Museum, Harley 5218, 15th century, fol. 116v: "Expliciunt complexiones simplicium medicinarum secundum Gallianum de Sancta Sophia phisicum."

[34] Munich, cod. lat. 12021, fol. 89rb, "Secuntur Consilia excellentissimi magistri Iohannis de S. Sophia." But at 61ra we read: "Expliciunt recepte extracte per magistrum Iohannem de Sancta Sophia de quodam receptario patris sui magistri Anthonii et magistri Bartholomei doctorum medicine et artium, 1447."

[35] Paris, Bibl. Nat. latin 6850, fol. 218va.

[36] Padua, Antoniana XX, 430, fol. 53.

[37] Venice, S. Marco VI, 74 (Valentinelli X, 79), fol. 175: "compositus ab olim

Pietro da Tossignano, of the late fourteenth century, is variously described in different manuscripts and incunabula of his several works as *famosissimus, celeberrimus, excellentissimus, clarissimus, egregius,* and even *reverendus.*[38] This did not cease even in late editions of the sixteenth century. In one of Paris, Ch. Wecheli, 1536, the title page reads:

Tractatus de regimine sanitatis, editus per insignem virum dominum P. de Tuxigano medicinae monarcham doctorem Bononiae, rerum experientia clarissimum.[39]

In another at Lyons in 1587 and again in 1597, he is still *clarissimus.*[40]

Angelus de Pergula was characterized by a student from Gubbio who was expounding an Aphorism of Hippocrates under him in 1397 as distinguished and most famous the world over.[41]

Latin manuscript 13 of the Staatsbibliothek at Munich was brought back from Padua by Hartmann Schedel and contains a list of the courses in medicine which he took there in the three years, 1464-1466.[42] One of his professors, Matheus de Bolderiis of Verona, died on September 7, 1465, and the manuscript contains a colored picture of him holding an herb in his right hand, and beneath it the following epitaph:

Epigramma doctoris eruditissimi Patavini Mathei de Bolderiis Veronensis ordinarii in practica Padue.

Heu! miserum mortale genus, nunc clarus Apollo
Occidit et medice maximus autor opis.
O! quotiens vite crudeli a funere raptos
Restituit, doctasque applicuit manus!
Hippocrates cessit medico diusque Machaon,
Hincque coronides filiridesque senex,
Hic Matheus eo defunctus funere quo non
Gloria sed tantum membra sepulta iacent.

Obiit autem prescriptus egregius doctor anno post nativitatem Christi Millesimo CCCC° lxv septimo die mensis Septembris.[43]

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monarcha et totius speculo mundi, artium et medicine doctore, Iacobo Forliviense, qui divinitate ingenii eum condidit claritate etatis sue dum foret vigenis uiernis." Also in VII, 7 (Valentinelli XI, 15).

[38] Giuseppe Mazzini, *Vita e opera di maestro Pietro da Tossignano,* Rome, 1926, pp. 118, 133 and 138, 140, 148, 147 and 149 and 152, 152.

[39] *Ibid.,* 115, 141.

[40] *Ibid.,* 144.

[41] Vatican, latin MS 9420, fol. 193vb: "Explicit 2a particula affor. Y. recollecta per me Melchiorem Iohannis Sabbi de Eugubio sub eximio artium et medicine doctore magistro Angulo(?) de Pergule(?) doctoris in orbe famosissimi quam particulam recollegi sub annis domini MCCClxxxxvii et ipsam perfeci die xxviiia mensis Iulii vz die Sabbati deo gratiam."

[42] CLM 13, fol. 223r.

[43] CLM 13, fol. 17v.

At fols. 18r-129v, follows the work of Matheus de Bolderiis on medicinal simples. After a blank page comes another colored picture of Bartholomew of Sancta Sophia and a copy of his epitaph on the wall of Padua:

Epigramma clarissimi doctoris Patavini Bartholomei de Sancta Sophia exaratum in muro Padue ubi itur de ecclesia Cathedrali ad curiam episcopalem.

Quem dedit alta domus Sancte propago Sophie
Hic iacet insignis preclarus Bartholomeus,
Doctor ille fuit virtutum iaspis in orbe.
Heu! quam lapse ruit medicina efracta columna
Tanto morte viri pro quo fleat ether et orbis.

Then at fols. 131ra-186ra follows a copy made by Schedel himself in 1465 in the mountains of Vicenza during a pest in Padua of Bartholomew's *Recipes on Liber nonus Almansoris* of Rasis.[44]

In another Schedel manuscript at Munich he has listed those "doctors who are depicted in the house of Matheolus of Perugia at Padua."[45] Mattioli was Schedel's teacher all three years and delivered the oration when Schedel got his degree.[46]

The doctors depicted were:

Petrus Apponus Consialiator(?)
Marsilius de Sancta Sophia
Jacobus Forlivias (*sic*)
Anthonus de Parma
Anthonus Cermisonus
Turrigianus
Gentilis Perusin. dictus Fulgicis (*?*)
Dinus Florentinus
Thadeus Florentinus
Hugo Senensis.

Of most of these worthies we have had occasion to speak already.

Antonio of Parma seems to have flourished early in the fourteenth century, since Tommaso del Garbo alludes to his opinion that vision was performed in the heart.[47] In one of the manuscripts of works by him at the Vatican he is called "viro in naturali philosophia et medicinali scientia elegantissimo."[48]

Turrigianus is for Pietro Torrigiano de' Torrigiani, a pupil of Taddeo Alderotti who flourished in the first part of the fourteenth century and

[44] CLM 13, fol. 186ra: "Finiunt Recepte super nono Almansoris Magistri Bartholomei de Sancta Sophia anno Mccccixv In montibus Vicentinis tempore pestis Padue per Hartmannum Schedel de Nuremberga."

[45] CLM 252, fol. 2v.

[46] CLM 350, fol. 79, copy made by Schedel; published by Wattenbach, *Forschungen zur deutschen Geschichte*, XI, 368. In a 16th century MS of Mattioli's tract on memory, Bassano del Grappa 1283, he is spoken of as "clarissimi philosophi et medici."

[47] *Thome de Garbo Florentini doctoris preclarissimi summa medicinalis* . . . , Venetiis per Bonetum Locatellum, 1506, fol. 65vb.

[48] Vatican, latin 4452, 14th century, fols. 1ra-47vb, in the explicit.

who is variously called Turisanus or Trusianus in printed editions of his works. The chief was *Plusquam commentum* on the *Microtechni* or *Ars parva* of Galen, in the 1557 edition of which he is called *medici acutissimi*.[49]

Dinus Florentinus is Dino del Garbo, father of Tommaso. In manuscripts of his writings he is called "most excellent" and "most famous and most excellent."[50]

Thadeus Florentinus is the same as Taddeo Alderotti, who died in 1295 rather than 1303,[51] as is shown by his epitaph in a manuscript at the Bibliothèque Nationale, Paris, which also contains his *Experimenta* and *Practica*:

Mille nonaginta transactis quinque ducentis
Iove sero primo Iunii sub nocte seconda
Migrat cunctorum Thadeus dux medicorum,
Cuius stat musa per singula climata fusa.
Errores stravit, tenebras ut sol radiavit,
Oremusque dominum, Pia mater sume Thadeum.
Amen.[52]

Christophorus de Recaneto began to teach medicine at Padua in 1467, the year after Schedel finished his residence there. But he had been teaching philosophy there from 1460 to 1465, and was called "summus in philosophia." In November, 1469, in *Recollectae* on the *Calculationes* of Richard Suiseth which were held under him he was called "huius artis principe," which presumably refers to medicine.[53]

[49] He is to be distinguished from Hieronymus Turrianus of Verona who died in 1505 (Borsetti, *Historia almi Ferrariae gymnasii*, Ferrara, 1735, II, 58), and from Turrianus of Cremona who wrote on the motion of the eighth sphere (Ranzovius, *Catalogus imperatorum* . . . , 1580, p. 29). Gentile da Foligno (died 1348) opposed Torrigiano's new theory as to the motion of the heart: see *J. Hist. Med. and Allied Sc.* 1955, *10*: 393.

[50] Cesena sinis. plut. 27, cod. 4, item 5: "Expliciunt Recollectiones de natura fetus reportate sub excellentissimo doctore artium et medicine magistro Dino de Florentia per magistrum Julianum (Galiatium?) Bononiensem . . . sub anno domini 1310 die 10 mensis Octobris." Oxford, Bodleian, Canon. Misc. 293, 15th century, fol. 1, "Incipiunt unguenta excelentissimi doctoris medicine magistri de Garbo civis Florentini"; fol. 42, "Expliciunt hic emplastra pulveres unguenta famosissimi et excellentissimi doctoris artium et medicine magistri Dini de Florentia, experta et probata et magistraliter compillata et facta, Amen"; fol. 51, "Expliciunt unguenta emplastra olea excelentissimi doctoris medicine magistri Dini de Garbo civis Florentini, Amen."

[51] As stated by Fabricius and G. Pinto, *Taddeo da Fiorenza*, 1888, 48 pp.

[52] BN latin 6964, 14th century, fol. 129rb; printed by Pansier in *Janus*, 1904, p. 511. But I take it directly from the MS.

[53] Venice, S. Marco VI, 149 (Valentinelli XI, 23), fol. 31r.

OSBORNE REYNOLDS OF MANCHESTER

Contributions of an Engineer to the Understanding of Cardiovascular Sound

VICTOR A. McKUSICK and H. KENNETH WISKIND

In the heart, sound is generated in association with its pumping action and the flow of blood. These audible vibrations which are grouped under the generic term "cardiovascular sound," include heart murmurs, the noises related to the closure of the heart valves, and various clicks, snaps, and "gallop" sounds. Some of these sounds are normal accompaniments of the healthy, well functioning heart. Others are valuable indicators of serious heart disease. Faced with the necessity of distinguishing between the benign and the malignant, the physician needs the clearest possible understanding of how sound is generated in the cardiovascular system.

Clinicians cannot fail to be impressed with how much of the phenomenology of cardiovascular sound, the descriptive aspect of the science, was contributed in the last century. They must continually marvel at the accomplishments of such masterly observers as the Parisian physician Potain (1825-1901) who used no other tools for the study of these sonic phenomena than the ear and the rigid monaural stethoscope.

Likewise, experimenters of the last century contributed significantly to the understanding of basic mechanisms involved in the generation of sound in the cardiovascular system. The experiments discussed here were not motivated by a desire to unravel the problems of heart murmurs. They are, however, no less pertinent. The work of Osborne Reynolds (1842-1912) is being appreciated more and more in its implications in seemingly diverse fields, including in an important manner several areas of biology. Interest in Reynolds, the man, has quickened *pari passu*.

Heart murmurs (the variety of cardiovascular sound to which Reynold's studies are pertinent) are, generally speaking, noisy sounds which result from a partial obstruction or leakage at valve orifices. Usually this obstruction or leakage results from damage to the valve by a disease process. Even when there has been no valvular disease, it seems likely that turbulence in the flowing blood is at least one common denominator in the generation of heart murmurs. Part of the explanation for certain

FIG. 1. Osborne Reynolds (1842-1912). Reproduction from a painting by Sir John Collier which now hangs in the Department of Engineering of Manchester University. (Courtesy of Professor Robert Platt, Department of Medicine, Manchester.)

varieties of heart murmurs becomes evident when one applies Osborne Reynolds' discoveries in hydrodynamics to the mechanics of blood flow ("hemodynamics").

Reynolds' experiments resulted in a formula which is a useful catalogue of certain of the factors which influence turbulence (and murmur-production). His concept of critical velocity assists our understanding of why murmurs occur under certain circumstances, and also why their character varies along certain lines when the parameters of the flow of blood and the dimensions of the conduit are altered.

Reynolds was interested in the generation of sound in flowing liquids. He studied particularly the noise produced by the flow of water through a tube with a localized constriction. This noise he attributed to the formation and subsequent collapse of bubbles at and just beyond the neck, a phenomenon which is distinct from turbulence. This phenomenon has since been referred to as "Reynolds' cavitation." Reynolds himself described it as "the boiling of water in an open tube at ordinary temperatures."

Under conditions of disease an anatomical set-up which is analogous to that in the Reynolds experiment on cavitation may occur in the heart or in the great vessels near the heart. It is not yet known whether cavitation in any form actually does contribute to the production of sound in the cardiovascular system, in health or in disease. It can be stated, however, that no investigation of the possibility has been undertaken. A review of Reynolds' experiments may serve to stimulate work along these lines.

Reynolds' Life in Survey

Osborne Reynolds (2) (4) was born in Belfast, Ireland, in 1842, the son of Rev. Osborne Reynolds, then principal of Belfast Collegiate School. Reynolds came from a line of clergymen—his father, grandfather, and great-grandfather were rectors at Debach-with-Boulge, Suffolk. Reynolds received his early schooling under his father, at that time headmaster of Dedham Grammar School in Essex. That his father's influence was a strong one is indicated in the following words, written by Reynolds in later years: "I had the advantage of the constant guidance of my father . . . also a lover of mechanics . . . of no mean attainment in mathematics and its application to physics."

At the age of 19, not intending to seek further formal education, Reynolds undertook an apprenticeship in mechanical engineering at the works of Edward Hayes at Stony Stratford. While with Hayes, how-

ever, his attention was drawn to " various mechanical phenomena for the explanations of which . . . a knowledge of mathematics was essential " (10). So piqued was the mind of the young apprentice that he decided to resume his formal education. Rapidly learning the Greek in which he was deficient, he enrolled in Queen's College, Cambridge. In 1867 he was graduated as Seventh Wrangler. (" Wrangler " is the Cambridge term for a member of the first class in mathematics. Reynolds' remarkable father had graduated Thirteenth Wrangler.)

After graduation, Reynolds entered the London office of Messrs. Lawson and Mansergh as a consulting engineer. One year later he accepted the newly created Chair of Engineering in Owens College, now the University of Manchester, a position he held until 1905, when he was forced to retire because of ill health. At the time he assumed the post there was only one other professorship of engineering in an English university. Reynolds became a Fellow of the Royal Society in 1877 and was the recipient of several honorary degrees and other academic honors.

Reynolds died at Watchet, Somerset, in 1912. He was twice married and left three sons and a daughter by his second marriage.

Reynolds as an Investigator and Teacher

Reynolds' personality has perhaps been described best by Sir Horace Lamb, long a colleague of Reynolds at Manchester, who wrote as follows (10):

> He was conscious of the value of his work, but was content to leave it to the mature judgment of the scientific world. For advertisement he had no taste; and undue pretensions on the part of others only elicited a tolerant smile. To his pupils he was most generous in the opportunities for valuable work which he put in their way, and in the share of credit which he consigned to them in cases of co-operation. Somewhat reserved in serious or personal matters and occasionally combative and tenacious in debate, he was in the ordinary relations of life the most kindly and genial of companions. He had a keen sense of humour and delighted in startling paradoxes, which he would maintain, half seriously and half playfully, with astonishing ingenuity and resource.

According to Gibson (10), a former student of Reynolds, " The training which his students received was the opposite of spoon feeding . . . . . the weaker brethren were apt to fall by the way." Most illustrious of those who survived the treatment was Sir J. J. Thomson (1856-1940), Cavendish Professor of Physics at Cambridge.

In lecturing Reynolds was likely to lead his audience into unexpected

excursions. "Struck by a new idea . . . he would begin to work at this on the blackboard, quite oblivious to his audience. To those who had an inkling of his object this, though unorthodox, was stimulating as giving some glimpse of the workings of a very acute mind when grappling with a new problem" (10).

The syllabus (27) of Reynolds' lectures for the four-year course in engineering shows the diverse fields he touched upon in his teaching as well as his research. Preparation for these lectures must have revealed new problems which required investigation, or new solutions to old problems.

Friends the world over subscribed funds for a portrait and presented it to the University of Manchester (Fig. 1). The symbolic significance of the spherical balls in the bowl is derived from Reynolds' concept of the "submechanics of the universe," a concept which had developed from observations on the different ways in which a pile of spheres of equal dimensions can be arranged with different volumes resulting. This line of thought was in evidence at least as early as 1885 when he read before the British Association a paper "on the dilatance of media composed of rigid particles in contact" (sand was what he had particularly in mind as an example). Reynolds apparently thought his long communication on "submechanics," read before the Royal Society in 1902, to be the crowning achievement of his scientific career. Most others, however, would not agree.

His Scientific Achievements

For nineteen years after accepting the chair in Engineering in Owens College, Reynolds worked without benefit of laboratory facilities. Finally, in 1887, the University equipped a laboratory for him (10). Most of his earlier experiments were of necessity performed in his own home. This practical consideration was probably largely responsible for his early concern for what J. J. Thomson called "outdoor physics": cometary phenomena, the solar corona, thunderstorms, and raindrop- and hailstone-formation. He studied the calming influence of rain on the sea and the damping of sound by fog. He concluded that the bursting of trees struck by lightning was due to conversion of moisture to steam.

Many of Reynolds' studies had a particular timeliness. For example, the occurrence of several harbor collisions of screw steam boats stimulated his study of the behavior of the screw in steering. About 1875 he wrote a note for *Nature* on the "projected" bridge across the Forth. The capsizing of several lifeboats in close succession, off the Lancashire coast,

stimulated theoretical studies and investigations in models. One of his later studies (1887) which had practical implications was entitled "On certain laws relating to the regime of rivers and estuaries, and on the possibility of experiments on a small scale." Herein he studied "the action of water to arrange loose granular material over which it may be flowing." Reynolds investigated the efficiency of belts and straps as communicators of work. The influence of an oil film in calming storm waves at sea interested him as a fascinating physical phenomenon with great practical significance: "There is nothing more striking than this phenomenon in the region of mechanics. A film of oil so thin that we have no means of illustrating its thickness, is yet able entirely to prevent an action which involves forces among the strongest we can conceive."

Reynolds' most significant studies were probably those on the refraction of sound by the atmosphere (1875), his studies on streamline and turbulent fluid motion (1877 ff.), of which more will be said presently, his study of friction, and his theory of lubrication.

Other investigations made by Reynolds concerned the mechanical equivalent of heat. For this experiment he designed a special brake-type instrument and invented a turbine pump (1875). It has been suggested (10) that one of the rare failures of Reynolds' acumen occurred in connection with this steam turbine. He concluded from observations in a small scale model that it could never be a successful competitor for the steam engine because of excessive leakage of steam between the blades and the casing. He failed to appreciate, however, that with full-sized models this factor would become relatively insignificant. Were it not for this misjudgment, a "Reynolds turbine" might today run the steamships and electric generators of the world.

Reynolds' studies of friction and lubrication have biological implications in connection with the physiology of movable joints. It is not surprising to find reference to Reynolds in Gardner's extensive review of articular physiology (9). Chalmers (2) called Reynolds' report on friction and lubrication "a masterpiece of mathematical analysis." Reynolds had based his theoretical studies on important observations of Beauchamp Tower (1845-1904), an expert experimentalist, who had been the object of bitter criticism. A letter attacking Tower and his work, published in *The Engineer*, February 29, 1884, is the plaint of the "practical" engineer against the experimental and presumably impractical engineer. It is a type of misunderstanding less frequently encountered in these days of mutual admiration between persons in practical and in theoretical or fundamental pursuits.

The letter, whose author refrained from identifying himself except by his initials, reads as follows (17):

Sir,

I have read with much interest and no small disappointment the article entitled, "What is Friction?", which appeared in the last number of *The Engineer*. I anticipated that Mr. Tower's researches would have had some practical value but as far as I can see they might just as well never have been undertaken.

To certain minds I have no doubt that it may prove valuable to know that friction between dry surfaces is not the same thing as friction between wet surfaces; to the great body of engineers the statement is simply useless. It is really a matter of no importance whatever that frictional coefficients vary with the speed, because the fact cannot be usefully applied. Again, we gain absolutely nothing of any value from the discovery, if such it be, that the use of an oil bath diminishes friction enormously. We cannot use oil baths, and the fact is therefore of no importance.

So-called scientific research is rapidly becoming nothing but a method by which considerable incomes may be earned finding out things of no earthly use to any mortal. The Institution of Mechanical Engineers ought to keep clear of this sort of thing, and its money ought to be spent in inquiries likely to prove of practical value to its members. There is no lack of subjects for investigation.

J. C. H.

Birmingham, Feb. 25th.

Today it is difficult to believe that in 1884 lubrication was not an established practice, just as it is difficult to imagine that the practical value of Tower's studies was not immediately evident. In that year, however, Reynolds presented his theoretical treatment of friction at the Montreal meeting of the British Association for the Advancement of Science, thereby silencing all doubts of the efficacy of oil lubrication and pointing the way for its successful application.

Several of Reynolds' studies, although they still have no practical application, are highly interesting: For instance, his first paper, "On the suspension of a ball by a jet of water" (1870), in which he analyzes the factors which hold a small celluloid ball in mid-air; and his last paper, "On the slipperiness of ice" (1899). At the time when his theory of lubrication was prominent in his mind, Reynolds had a commonplace but for him thought-provoking experience. While heating a soldering iron, he noted that when it was hot to the point of melting the metal, the blade slipped easily over the metal surface. He was immediately reminded of the sliding of the skate on ice and conceived the idea that the weight of the skater might melt the ice beneath the blade and that the water so

produced perhaps acts as a lubricant; hence, the slipperiness of ice. Using Lord Kelvin's determination of the lowering of the melting point of ice under pressure, he calculated that below a certain temperature ice would no longer be slippery for a skater of average weight. He waited in vain for a " cold snap " to test his theory but found confirmation in Nansen's book on Greenland in which the author made a casual comment that the ice was not slippery at the very low temperatures of the northland.

His Methodologic Approach

Reynold's approach was always theoretical, and the laboratory was used mainly to test his theories, or to obtain values for his formulae. He appears to have subscribed to the philosophy of Galilei, in effect, that one does experiments largely to convince others of that which has been clear to oneself all along. As noted earlier, however, there were practical reasons for his resorting to the laboratory late in the investigation of problems.

After he had carried mathematical analysis as far as possible, Reynolds used models extensively in the analysis of problems. He devised several types of models, and although this approach was certainly not original with him, he did develop it to an extent seldom equalled. He used models of ships in the study of marine propulsion; and of lifeboats in trying to discover the factors which caused lifeboats to capsize in heavy seas. He produced a model of the solar corona by placing a charged metallic sphere in a partial vacuum. His model for studying turbulent and streamline flow will be discussed in a moment. In his study of the formation of rain, snow, and hailstones, he blew finely powdered plaster of Paris into a jet stream and then, by using a spray of ether and water in air, produced artificial raindrops whose characteristics corroborated his theory.

One of the large scale phenomena which Reynolds studied by means of models, was bed-formation in rivers and estuaries. He employed fine Calais sand. Although the selection of this sand was apparently intuitive, subsequent tests have revealed that the size of grain was almost ideal. Reynolds worked out the appropriate dimensionless ratios; the same number of tides were applied to the model as would occur in the period for which prediction was to be made. He called attention to the results of his experiments, in his own words, ". . . because they seem to afford a ready means of investigating and predetermining the effects of any proposed estuary or harbour works; a means which . . . I should feel it madness to neglect before entering upon any costly undertaking."

Reynolds was not customarily an interesting nor even a particularly lucid writer. His memoir on fluid flow is written in stiff and awkward prose. He was a lucid thinker, however, and was able to see a simple explanation for apparently complex situations. As with many other scientists, past and present, the problem was one of communication. Oddly enough, on rare occasions, Reynolds' writings are delightfully readable. The following is one of these exceptions, the introduction to a paper read at the Royal Institution of Great Britain in 1897. It refers to his use of the simple artifice of dye injection to reveal the mysteries of fluid flow.

In his charming story of The Purloined Letter, Edgar Allan Poe tells how all the efforts and artifices of the Paris police to obtain possession of a certain letter, known to be in a particular room, were completely baffled for months by the simple plan of leaving the letter in an unsealed envelope in a letter rack, and so destroying all curiosity as to its contents; and how the letter was at last found there by a young man who was not a professional member of the force. Closely analogous to this is the story I have to set before you tonight—how certain mysteries of fluid motion, which have resisted all attempts to penetrate them are at last explained by the simplest means and in the most obvious manner.

This indeed is no new story in science. The method adopted by the Minister D., to secrete his letter, appears to be the favorite of Nature in keeping her secrets, and the history of science teems with instances in which keys, after being long sought amongst the grander phenomena, have been found at last not hidden with care, but scattered about, almost openly, in the most commonplace incidents of every-day life which have excited no curiosity.

No principle was better illustrated in Reynolds' own work than that great truths of nature lie in open view of him who has eyes to see them. This point, colorfully expressed in the preceding quotations, was again introduced in his last short paper:

Ice is not the only slippery thing in the world, but it is the only one of the solid substances which, in the condition nature has left them on the surface of the earth, possesses the remarkable property of perfect slipperiness. This being so it is certainly remarkable that there appears to have been little or no curiosity as to the physical significance of this unique property. Speaking for myself it is simply explained; ice was slippery when I was born, I never knew it otherwise, and to put it shortly, it was slippery simply because it was ice, whereas now it seems to me that of all the secrets nature has concealed by her method of deadening curiosity by leaving them exposed, in this her method has been most successful.

Experiments Bearing on Cardiovascular Sound-Turbulence

It was through his study of fluid motion, or hydrodynamics, that Reynolds made his great contribution to our understanding of heart murmurs. His study developed out of problems pointed out by Jean L. M. Poiseuille (1779-1869), the physician-physiologist-physicist who had examined the physical factors governing flow through tubes, and who had formulated the interrelationships of pressure, flow, and resistance. The resulting law bears the name of Poiseuille and often that of Hagen[1] as well. It can be construed as the analogy in fluid mechanics (and hemodynamics specifically) of Ohm's law in electricity.

Poiseuille found that the direct proportionality of resistance to velocity broke down in pipes over about 0.6 mm. in diameter. Somewhat later, Darcy reported to the French Academy of Sciences, in 1845, that Poiseuille's law did not hold for flow of water through one-half inch pipes at velocities in excess of six inches per second. Darcy observed that at a certain pressure and velocity, volume of flow was no longer directly proportional to pressure head. An increase of pressure head did not bring the anticipated increase in flow. This was the same as saying that resistance to flow was greater at higher velocities.

Thus Reynolds undertook his study of fluid motion, because of "the failure of hydrodynamics to explain why the resistance [to flow] is in some cases proportional to velocity, and in others to the square of the velocity."

After his usual theoretical analysis, Reynolds attacked the relationship between resistance and velocity by devising a "large glass tank" (see Fig. 2). To demonstrate the pattern of flow, Reynolds injected dye into the midst of a stream moving through a glass tube within a tank, which also had glass walls to permit clear observation of the phenomena of flow. *The Proceedings of the Manchester Literary and Philosophical Society* for February 1877 (24) carried the first notice of the ingenious demonstration of various forms of whirlpool or vortex motion. The note concludes by stating that "Professor Reynolds' object in showing these experiments was to illustrate the importance of the method of study rather than the intrinsic importance of the results already obtained, which are not as yet sufficiently complete for publication."

Six years passed before Reynolds' work in this glass tank culminated

[1] Gotthilf Heinrich Ludwig Hagen (1797-1884) also recognized the transition from laminar to turbulent flow about 1854 (16). He noted that the transition point was temperature-dependent but did not relate this observation to viscosity.

in a published memoir (25), describing differences between turbulent and streamlined flow. In presenting this paper to the Royal Institution, he projected on a screen the patterns produced by the dye at various rates of flow (Fig. 3). At low velocities of flow, streamlining was present

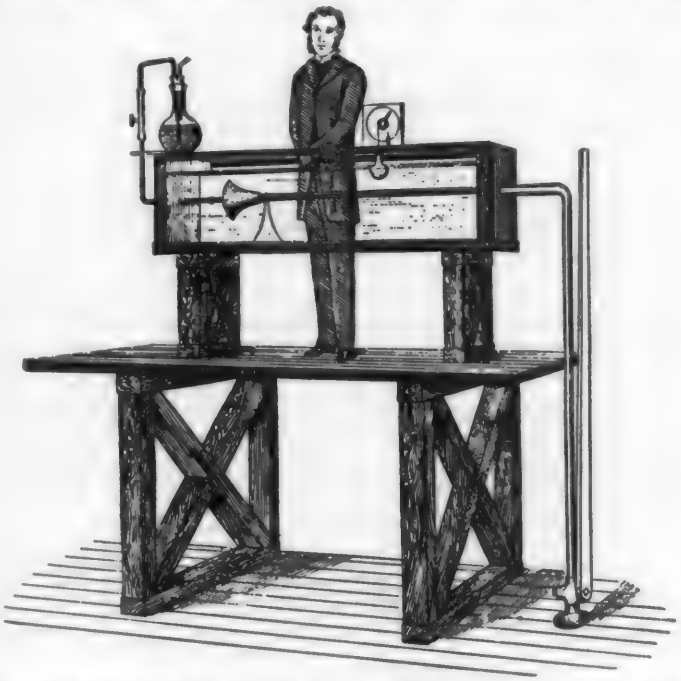

FIG. 2. The model built by Reynolds to demonstrate turbulent and streamline flow. A long glass pipe with attached funnel-end drained off water from the tank when the valve was opened by means of the long handle. The wash-bottle sitting above the water tank contains dye which, via the small glass tube shown in the sketch, could be injected into the stream of water leaving the tank. It is evident how "critical velocity" could be investigated in such a model. From Reynolds' publication (25).

On a visit to the Department of Engineering of the University of Manchester in the summer of 1958, we saw the model used by Reynolds in his studies of the patterns of flow. The sketch above is an accurate portrayal. The apparatus is still used in the student laboratory for determining the Reynolds number.

and the line of dye remained intact. At higher velocities the line of dye broke up into a cloud. Examination with a strong light demonstrated that this cloud was made up of many little vortices, or eddies. From these experiments Reynolds developed the concept of critical velocity (the

velocity at which "direct," streamlined, or laminar, flow becomes turbulent, or sinuous). He set out to define the factors determining the value of this critical velocity. By making appropriate variations in the experimental set-up, Reynolds was able to demonstrate that the critical velocity varied directly with the viscosity of the fluid, and inversely with its density

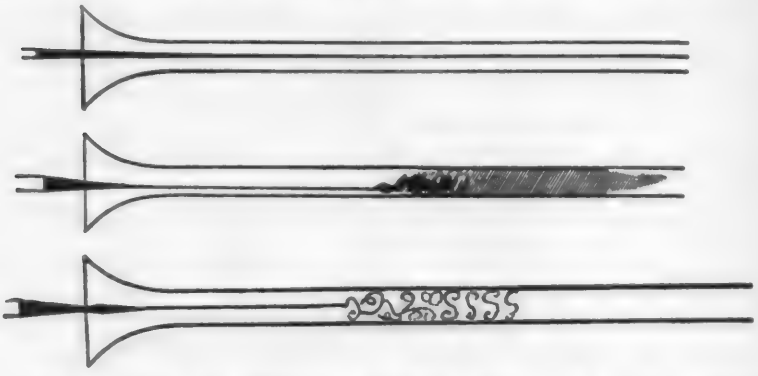

FIG. 3. Patterns of flow demonstrated by the model shown in Fig. 2. Top: Streamline flow at velocities below the critical level. Middle: Turbulent flow at velocities of flow in excess of the critical level. Below: Semi-schematic illustration of vortices in turbulent flow as viewed by intense light. From Reynolds' publication (25).

and with the caliber of the conduit. All these factors he collected in one formula for a dimensionless quantity which has since become known as the Reynolds number:

$$\text{R. N.} = \frac{\text{velocity} \times \text{density} \times \text{diameter}}{\text{viscosity}}.$$

The Reynolds number is an indication of the ratio of inertial forces (the numerator) to viscous forces (the denominator) in shear flow, i. e., flow in which velocity varies with distance from the wall of the tube. When the Reynolds number exceeds a certain value through appropriate variation in one or more of its parameters (see below for qualifications), turbulent flow sets in. The law described by the critical Reynolds number is a so-called "law of similarities" because it defines a point of resemblance of all fluids. Reynolds determined a value of 1900.[2]

[2] Obviously the value of the Reynolds number depends on whether diameter or radius is used in its calculation. Engineers generally use diameter, just as Reynolds did, whereas physicists and biologists usually use radius.

Note that the Reynolds number is dimensionless. Although thought along the lines of dimensionless ratios can be traced back at least to Galilei (7), the Reynolds number is one of the earliest and most outstanding examples. Laws of similarity and dimensionless values have since become widely used in the physical sciences. The Reynolds number as a general concept was important to the methodology of physical theory, as well as being an important specific contribution to hydrodynamics.

Reynolds' method of dye injection has been used by others for studies of fluid motion in both physical and biological systems (e. g., refs. 14, 22, 23). His demonstration model has recently been modified by Jerrard and Burton (15) in such a way that the dye injection is done in a fluid chamber contained in the slide holder of a projection lantern.

Pertinence of experiments: As demonstrated by Reynolds, turbulence is an inefficient variety of flow. This explained the more rapid loss of pressure head at high flows, which Poiseuille and Darcy had observed. The lost energy manifests itself predominantly as heat, but a small part is converted into sound energy.

The importance that is currently given to turbulence in the genesis of heart murmurs is well indicated by the light-hearted ditty [8] with which, sung in barbershop quartet style, Dr. Alan Burton, Professor of Biophysics in the University of Western Ontario, regales his medical students:

> Streamline flow is silent.
> Remember that, my boys.
> But when flow is turbulent,
> There's bound to be a noise.
>
> So when your stethoscope picks up
> A bruit, murmur, sigh,
> Remember that it's turbulence,
> And you must figure why.

Although the critical Reynolds number has validity for a wide range of fluids, its separate determination for whole blood is indicated because of such anomalous characteristics of blood as its non-homogeneity. In 1924, Müller (18) estimated the transitional Reynolds number for ox-blood to be between 700 and 1000 (using radius). Coulter and Pappenheimer (3) determined a value of 970 ± 40. They subscribed to the previously advanced suggestion that in the flow of blood the red blood cells are not distributed uniformly across the lumen of the vessel but that there is a plasma " sleeve " on the periphery, with a core of concen-

[8] Included with Professor Burton's permission.

trated red blood cells in the center. In the study of Coulter and Pappenheimer it appeared that at the transitional Reynolds number (determined by means of a hydraulic method) turbulence developed only in the plasma sleeve. At much higher Reynolds numbers there was still evidence of axial orientation of the disc-shaped red blood cells, as indicated by measurement of electrical conductivity.

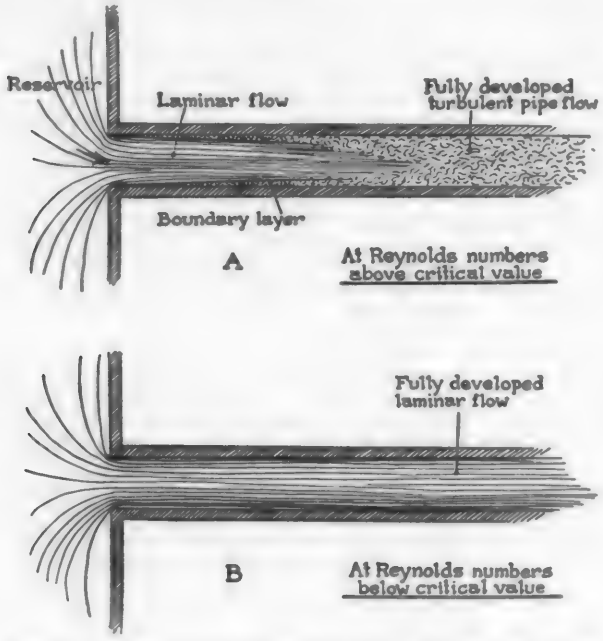

FIG. 4. All flow in the "entrance length" is laminar. The Reynolds number describes the flow pattern downstream at a distance such that the definitive pattern is established.

Before attempting to apply the Reynolds number to the production of murmurs in the heart and great vessels, it must be recalled that Reynolds dealt with a highly simplified system, using long straight tubes of uniform caliber. Roughness of the lining makes a difference in the transitional, or critical, velocity. The Reynolds criterion is applicable only at a certain distance from the entrance to the tube, where there is so-called fully developed flow and beyond which flow does not change in pattern. As is illustrated schematically in Fig. 4, in the model in which Reynolds' number is applicable, flow which is said to be "fully developed" cannot be expected in the "entrance length" where flow is essentially

laminar at flows both above and below the critical velocity. Furthermore, the complex geometrical configuration of the normal heart and great vessels, and the even more complex configurations associated with diseased valve-orifices, make the Reynolds number inapplicable in absolute or quantitative terms. Also Reynolds' theory was based on steady flow, whereas flow in the cardiovascular system is pulsatile. Reynolds (26) was well aware of the simplifying assumptions of his model:

If water enter a pipe without tumultuous motion, such motion will be generated if

$$\frac{\rho DV}{\mu} \text{ is greater than } 1900$$

These limits have been for some time established as the limits of the criterion K[4] for straight smooth pipes, and having thus found the limiting values of the purely numerical physical constant, it still remains to find the form of the function corresponding to $\rho DV/\mu$ under other boundary conditions such as parallel pipes with sections other than round and smooth and for converging or diverging boundaries. Such determinations present analytical difficulties which have not been altogether overcome. But it has been possible to obtain from analysis evidences that in converging pipes the critical velocity increases very rapidly with the rate of convergence and, on the other hand, that the critical velocity in diverging pipes diminishes very rapidly as the divergence increases.

Of the parts of the cardiovascular system where significant mumurs occur, it is possibly in the first portion of the aorta and in the main pulmonary artery that murmur-production follows most closely the simplified considerations of the Reynolds number. Of course, as pointed out above, one characteristic of the Reynolds model, namely, a sufficiently long straight tube for fully developed flow pattern, is not precisely duplicated.

If the calculations of Prec, Katz, *et al.* (21) are to be accepted in quantitative terms, it appears that early in the period of normal contraction of the heart the critical velocity is closely approximated, in fact exceeded, in the portion of the aorta and pulmonary artery closest to the heart. Even slight increases in velocity, or decreases in viscosity, may result in turbulence and perhaps murmur-production. This fact is probably related to the fact that murmurs audible with the stethoscope occur frequently over the pulmonary artery in normal persons. Such murmurs are likely to be limited to the very first part of the period of contraction of the ventricle, at which time the velocity of ejection is maximal. They occur especially often in children with vigorous circulations. Slight mur-

[4] Reynolds number in our terminology.

murs which can be demonstrated in graphic recordings, can be produced in most subjects by exercise and by the injection of adrenaline, both of which increase the velocity of blood flow.

The use of very sensitive "pick-up" devices on the surface of the chest demonstrates a murmur in 100% of subjects. Furthermore, when a special sensing device (barium titanate ceramic transducer) on the tip of a cardiac catheter is passed into the pulmonary artery, a murmur occurring at the point in the heart cycle when blood flow is most rapid is also found in all subjects.

Reduction in the number of red blood cells favors the development of the type of "normal" murmur just mentioned (8), as does also overfunction of the thyroid gland. These last two disorders—anemia and thyrotoxicosis—operate in the generation of murmurs mainly by affecting viscosity (19) and velocity, respectively. In the case of anemia, increased cardiac output increases the velocity of flow, likewise playing a role in murmur-genesis. (In anemia, a decrease in density opposes the development of turbulence but the change of viscosity and velocity outweighs the density-change.) It is interesting further to note that in multiple myeloma there is likely to be severe anemia but often the anticipated murmur of anemia is not heard because the disease also often produces a pronounced increase in the protein content of the blood, with corresponding increase in viscosity.

Increased volume, and therefore increased velocity of flow across the pulmonary orifice, is observed in certain congenital heart conditions, such as when there is a perforation between the two auricles, with recirculation of blood through the right side of the heart. In this condition (*atrial septal defect*), a murmur is produced at least in part because of the high flow. These patients usually have dilation of the pulmonary artery as well, so change in the velocity factor is not the only one responsible for murmur. Increased velocity of flow on a comparable basis is seen at the mitral valve orifice in other congenital heart conditions. At least in part, it is responsible for the rumbling murmur produced at the mitral valve and heard in patients with these particular malformations.

Although the Reynolds formula has only limited quantitative applicability in most murmur-production, it is highly useful as a catalogue of some of the major factors concerned. In cyanotic congenital heart disease, there is usually a marked increase in the number of red blood cells and in the viscosity of the blood; murmurs are likely to be greatly diminished, as compared to the anatomically identical condition with a normal number

of red cells (8). In the bruit over the thyroid gland in thyrotoxicosis and over the uterus in pregnancy, increased velocity of flow and dilatation of the channels make for murmur-production, the first through influence on the velocity factor and the second on the dimension factor of Reynolds' formula.

Another variety of murmur which behaves in accord with Reynolds' concept of the critical velocity, is the hum sometimes heard over the veins of the neck as a normal occurrence, predominantly in children who have faster circulations. This murmur is exaggerated in the sitting position which gives a gravitational acceleration to flow in the veins of the neck, and in inspiration, which also accelerates venous flow. Turbulent flow of blood through the veins of the neck seems to be responsible for this so-called " venous hum." An increase of the hum is observed in the presence of anemia.

Even though the Reynolds formula cannot be used to describe the complex situations in connection with obstructions and leaks of heart valves (valvular stenosis and regurgitation), it is still highly pertinent. All of the following conditions are accompanied by changes in murmurs in the direction one would predict on the basis of Reynolds' concepts: increased velocity of flow through a stenosis; abrupt increase in diameter of the channel (as with aneurysm of the aorta or other vessel); reduction in viscosity with anemia; increased volume and velocity of flow across valve orifices with shunts; increased velocity of flow occurring with thyrotoxicosis, anemia, adrenaline, or exercise.

It is an over-simplification to equate turbulence directly to murmur. The mechanisms that tie the two together are relatively unexplored. Certainly, however, the character of the structural elements of the cardiovascular system, the boundary factors, the walls of the heart and blood vessels, are of importance. In rigid-walled tubes, flow at a velocity well above the critical value may produce little sound, whereas in soft wall tubes with properties comparable to those of the aorta, a loud " murmur " may occur. In general, turbulence is *per se* an inefficient noisemaker. Although the mechanism by which murmurs are produced as a result of turbulent flow is probably an indirect one, the relationships outlined in the foregoing remarks remain significant.

Seemingly Reynolds himself was not impressed with turbulence as a source of noise in moving fluids. He thought cavitation to be the principal source of such noise.

Experiments Bearing on Cardiovascular Sound: Cavitation

Any formation of bubbles in a liquid is, in a general sense, *cavitation*. Rough calculations from available data and other arm-chair considerations may suggest that cavitation does not occur in the cardiovascular system and indeed there is no direct evidence that it does, either in health or disease—with one exception. That exception has been the journalists' field day, decompression sickness, or caisson disease, which occurs in divers, builders of tunnels, and aviators. In this sickness, the formation of bubbles of atmospheric gases in the body is responsible for the symptoms. In biological systems, bubble formation is also responsible in large part for the damage to cells from very intense ultrasonic vibrations—bubbles form from the low pressures associated with the troughs. Despite the paucity of evidence, it is important to investigate cavitation as a mechanism of heart murmurs.

A particularly clear and simple case of cavitation was demonstrated by Reynolds at a meeting of the British Association for the Advancement of Science at Oxford, in 1894. " Reynolds' cavitation," as Harvey (13) calls it, results when liquid flows with appropriate velocity through a pipe which first narrows and then widens. This is also the system which, architecturally at least, is most analogous to the cardiovascular system, when, for example, valvular stenosis or coarctation of the aorta is present. In the Reynolds model, if velocity of flow is high, pressure at the throat may, for dynamic reasons described by the Bernoulli equation, fall below the vapor pressure of the fluid itself, or below the tension of dissolved gases. If so, bubbles develop at the throat. After passing the throat the fluid flows on as a very turbulent, foaming mixture of liquid and bubbles. (This is what Reynolds referred to as " the boiling of water in an open tube at ordinary temperatures.") Farther on the jet impinges against more slowly moving liquid which fills the whole breadth of the pipe. Owing to a rise in pressure the vapor condenses, or gases redissolve, and the cavities collapse (or collapse, rebound and collapse), producing a loud murmur.

As early as 1754 Leonhard Euler (1707-1783), a student and friend of the Bernoullis and like them interested in both mathematics and hydrodynamics, recognized the possibility of cavitation in hydraulic machines (6). Shortly after Reynolds' studies of cavitation, Sir John Thornycroft and S. W. Barnaby (1, 28) investigated cavity-formation in connection with screw propellers. There is, therefore, adequate historic justi-

FIG. 5. General (top) and close-up (below) views of Reynolds' model for demonstrating cavitation. The arrow shows the direction of flow of water. The model he constructed used glass tubing which had an internal diameter of ½ inch and which he drew out in a gradual constriction with a minimal internal diameter of 1/10 inch. When water flowed through at the rate of 50 feet per second at the neck there was no sound, but at a velocity of 54 feet per second "a distinct sharp hiss" became audible.

fication for associating Reynolds' name with the particular variety of cavitation under discussion.

One can easily demonstrate cavitation by means of the same model as Reynolds used. When a glass tube with a constriction is connected to a water faucet and water runs through it, a cloud of bubbles is seen to appear at the neck and disappear a certain distance beyond (Fig. 5).

Cavitation in general is a phenomenon of great importance to engineers. Cavitation increases the noise produced by propellers, and by submerged bodies such as submarines or vessels, if there are projecting objects such as rivet heads. Furthermore, cavitation represents wasted energy, and when present it reduces the efficiency of propellers or water turbines and increases the drag on submerged vessels. Finally, cavitation results in striking corrosion of propellers and other structures.

In connection with the generation of murmurs, the phenomenon of cavitation might have quantitative significance because cavitation noise is more intense than noise resulting from turbulence.

Although cavitation of a special form (local cavitation with valve closure, in the center of eddies, etc.) may occur in the diseased, and possibly the normal, cardiovascular system, the development of Reynolds' cavitation would theoretically appear unlikely because of the following consideration: 1) The soft walls which constitute the analogue of the Reynolds tube would be expected to collapse because of Bernoulli effects. 2) Damage to the red blood cells which would be subjected to violent pressure changes might be predicted, but has not been observed. 3) Cavitation would be expected to produce intolerable damage to the vascular system. Damage of the magnitude expected has not been observed. 4) It is doubtful that pressures and velocities of flow sufficient to produce cavitation occur in the human circulatory system. Final conclusions about the possible role of cavitation in the generation of cardiovascular sound must await experimental evidence.

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A HISTORY OF THE WESTERN DENTAL COLLEGE

RALPH W. EDWARDS*

Formal dental education in Kansas City, Missouri, had its beginning with the founding of the Kansas City Dental College (1881-1919) as the dental department of the Kansas City Medical College.[1] It was a privately owned enterprise and continued as such during the period of its existence. The following year the Kansas City College of Dental Surgery (1882-1900) was established, but it led an elusive existence in the various dental offices of its founders, proving to be a diploma mill, and finally was closed by the Missouri State Board of Dental Examiners.[2]

The Western Dental College (1890-1919) was the third school of dental education to be founded in Kansas City. In 1890 Kansas City was a community of 132,716,[3] with sixty-one dentists serving the populace.[4] There is reason to doubt the necessity of another dental school at that time, but doubtless the success of the Kansas City Dental College inspired others to form a new institution. (The Inter-State Dental College [1895-1896], the fourth dental school in Kansas City, was opened in 1895, but continued in existence only one year and graduated one class.)[5]

Most prominent in the organization of the Western Dental College was Doctor Drury J. McMillen (1846-1913), a graduate of the Missouri Dental College (Washington University), who came to Kansas City in 1886 after nine years of practice at Brunswick, Missouri. A vigorous individual and an excellent organizer, it was not long until he had interested prominent professional men of Kansas City in establishing another dental school.

It was on June 5, 1890, that articles of association and incorporation were compiled, forming the Western Dental College of Kansas City,

* From the University of Kansas Medical Center, Kansas City 12, Kansas.

[1] Ralph W. Edwards, The Kansas City Dental College. *J. Missouri Dent. Ass.*, 1947, *27*: 287.

[2] Ralph W. Edwards, The Kansas City College of Dental Surgery. *J. Missouri Dent. Ass.*, 1947, *27*: 238.

[3] Chamber of Commerce, Kansas City, Missouri.

[4] *Hoye's City Directory of Kansas City, Mo.* Vol. XX, 1890, p. 814.

[5] Ralph W. Edwards, A History of the Inter-State Dental College. *Kansas City District Dental Society Bulletin*, 1952, *28*: 10.

Missouri, with a capital stock of $3,500, 350 shares with a par value of ten dollars each.[6] The purpose of the corporation was:

> To establish and conduct a dental college in Kansas City, Missouri, for the purpose of teaching and training pupils in the profession of dentistry, which teaching and training shall include all the necessary instruction in anatomy, physiology, chemistry, science, and medicine so far as the same may in the judgment of the faculty of said college be deemed necessary for the purpose of thoroughly fitting and qualifying students to pursue the profession of dentistry, with power to confer all appropriate degrees.[7]

The twenty stockholders, all of Kansas City, Missouri, follow:

	Shares		Shares
H. S. Lowry	30	T. J. Beattie	20
J. W. Heckler	60	C. C. Hamilton	5
E. E. Shattuck	30	S. C. Wheat	5
D. J. McMillen	30	J. W. Aiken	5
J. S. Letord	30	D. C. Lane	2
E. D. Carr	30	S. B. Prevost	5
H. S. Thompson	30	Elliot Smith	2
W. G. Price	30	I. D. Pearce	5
J. M. Gross	10	W. S. Dedman	10
I. H. Kinley	10	J. H. Cromwell	1

These articles were filed on June 21, 1890, and incorporation was granted on June 24, 1890.[8] Of the incorporators, all were dentists except T. J. Beattie and C. C. Hamilton, physicians, J. H. Cromwell, a student of J. W. Heckler, and I. H. Kinley, a lawyer.[9]

The first session of the College opened on Wednesday, September 17, 1890,[10] with an enrollment of nine seniors and fifty-one juniors.[11]

The admission requirements for the school stated that:

> The applicant must present satisfactory evidence of a good moral character and will be required to pass a satisfactory examination in the branches usually taught in the common schools, or present a diploma or certificate of examination from a reputable educational institution.[12]

The length of the curriculum in dentistry at that time was two years,

[6] Recorder's Office, Kansas City, Jackson County, Mo. Book 413, pp. 466-469.
[7] *Ibid.*, p. 468.
[8] Dwight H. Brown, Secretary of State, Jefferson City, Missouri. Personal communication, March 24, 1944.
[9] *Hoye's City Directory of Kansas City, Mo.* Vol. XX, 1890.
[10] *Western Dental College, first annual announcement*, 1890.
[11] *Western Dental College, second annual announcement*, 1891.
[12] *See* footnote 10.

although in 1891 the curriculum was increased to three years. The first graduating class, composed of C. J. Sawyer, M. D., J. H. Cromwell, H. B. Lowry, H. B. Heckler, J. D. Roy, S. S. Brown, C. W. Lukens, B. T. Edmiston, and Frank Nelson received the degree of Doctor of Dental Surgery on March 13, 1891.[13]

The first faculty of the college follows:[14]

J. D. Griffith, M. D., Professor of Oral Surgery
J. I. Eggers, M. D., Associate Professor of Anatomy
T. J. Beattie, M. D., Associate Professor of Anatomy
J. S. Sharp, M. D., Professor of Materia Medica and General Pathology and Therapeutics
Claude C. Hamilton, M. D., Ph. G., Professor of Chemistry
H. O. Hanawalt, M. D., Professor of Physiology
H. S. Lowry, D. D. S., Professor of Prosthetic Dentistry and Dental Metallurgy
D. J. McMillen, D. D. S., Professor of Operative Dentistry and Dean of Faculty
J. M. Gross, M. D., D. D. S., Professor of Dental Pathology and Therapeutics

Special Lecturers

L. P. Haskell, D. D. S.	Dr. J. S. Letord
C. C. Carroll, M. D., D. D. S.	Dr. I. D. Pearce
Willis P. King, M. D.	R. Wood Brown, M. D., D. D. S.

Demonstrators of Operative Dentistry

Dr. J. . Letord	Dr. A. J. McDonald
Dr. H. S. Thompson	Dr. S. C. Wheat
Dr. S. B. Prevost	Dr. George Ashton

Demonstrators of Mechanical Dentistry

Dr. J. W. Heckler	Dr. W. G. Price
Dr. E. D. Carr	Dr. Elliot Smith
Dr. E. E. Shattuck	Dr. J. W. Aiken

Special Clinical Instructors

Dr. I. D. Pearce	Dr. C. C. Carroll
Dr. D. J. McMillen	Dr. L. P. Haskell
Dr. L. D. Hodge	Dr. C. E. Esterly

The first location of the Western Dental College was at Twelve West Tenth Street.[15] This was a four-story building, the third floor of which

[13] *Dental Cosmos*, 1891, *33*: 405.
[14] *See* footnote 10.
[15] *Ibid.* As this structure was razed some years ago, some doubt existed as to the exact location of the Western Dental College site. A photograph of the college in one of the early catalogues showed that it was in a building, the ground floor of which was

was occupied by the dental school. As the overall dimensions of the Zahner building were approximately 28 feet by 140 feet, it was not long before the third floor quarters of the dental school were found to be inadequate, and additional space was acquired by taking over the second floor of the building.[16] Thus the school continued until 1896, when expansion again became necessary.

On October 5, 1896, the Western Dental College opened its seventh year in the Navajo Building at 716 Delaware Street.[17] The school occupied the entire second floor of the building,[18] and remained there until 1900, when, after a decade of existence, a permanent home for the school was sought.

There is good reason to believe that by this time a controlling interest, if not absolute ownership of the Western Dental College corporation, had passed to Doctor McMillen, as the next move of the Western Dental College was to a building built and owned by Doctor McMillen. Doctor McMillen was reputed to have amassed a considerable fortune in real estate operations during the boom days in Kansas City and, therefore, was able financially to undertake a building project of this nature.[19] The building, a four story structure with storerooms on the ground floor, was located at the southwest corner of Eleventh and Locust Streets. The tract of land occupied by this building is now a part of the square block of ground occupied by the City Hall.

On October 2, 1900, the Western Dental College opened its eleventh session in this building, occupying the three upper floors,[20] and remained at this location until its merger with the Kansas City Dental College in 1919.

Under the guidance of Doctor McMillen, the Western Dental College proved to be a successful enterprise. He continued as the owner and dean of the school until his death on April 2, 1913.[21]

occupied by the Zahner and Battell Manufacturing Company, hardware merchants. Frank L. Zahner, a son of one of the founders of Zahner and Battell, and at present of the Zahner Manufacturing Company of Kansas City, was instrumental in offering positive identification of the location of the building. The building site is now occupied by the savings department division of the First National Bank and is designated by the number Fourteen West Tenth Street.

[16] Frank L. Zahner, Kansas City, Missouri. Personal comment, October 10, 1944.

[17] *Western Dental College, seventh annual announcement*, 1896.

[18] Harry M. McFarland, Kansas City, Missouri. Personal comment, September 28, 1944.

[19] Hugh G. Tanzey, Kansas City, Missouri. Personal comment, July 5, 1944.

[20] *Western Dental College, eleventh annual announcement*, 1900.

[21] *History of Dentistry in Missouri*. Fulton, Mo.: Ovid Bell Press, Inc., 1938, p. 143.

The Western Dental College was a notable example of an institution that was owned, developed, and controlled by a single individual. Its great strength was in Doctor McMillen. Its great weakness was in the fact that it was a one-man institution, without organization to perpetuate its existence. Following the death of Doctor McMillen, serious difficulties beset the school, and, possibly because of lack of professional leadership, the school began to deteriorate. There was dire need of students.

In its efforts to obtain students the school employed questionable methods of advertising and inserted in a well-known publication with a national circulation the following advertisement:[22]

DENTISTRY PAYS BIG MONEY!
Demand for properly educated dentists greater than supply. WESTERN DENTAL COLLEGE has complete equipment and facilities. Low tuition. No extras. FREE CATALOG. Address.
WESTERN DENTAL COLLEGE, 1101 Locust St., Kansas City, Mo.

That the foregoing advertisement with a " big money " appeal did not meet with professional favor is evidenced by a protest which stated " [It is an] injury to the dental profession to have a misleading advertisement . . . in a magazine with such a large circulation as the Saturday Evening post. . . ." [23]

Perhaps public reaction to this " trade school " method of obtaining matriculants for the study of dentistry also was unfavorable for it was not long until the school was so pressed for students that it was admitting individuals with insufficient preparatory work. Before long this irregularity became known.

Within two years of Doctor McMillen's death, charges were preferred by the Missouri State Board of Dental Examiners against the Western Dental College for admitting students without sufficient entrance requirements for the study of dentistry.[24, 25]

On April 12, 1915, the first hearing of these charges against the school was held in Kansas City, Missouri.[26]

Pursuant to notice heretofore given, the State Board of Dental Examiners for

[22] *Saturday Evening Post*, 1913,*186*: August 2, p. 40, August 16, p. 44, August 30, p. 42.
[23] *Dental Digest*, 1913, *19*: 636.
[24] Hugh G. Tanzey, Kansas City, Missouri. Personal comment, July 5, 1944.
[25] George E. Haigh, Jefferson City, Missouri. Personal communication, October 11, 1944.
[26] Howard C. McCoy, Secretary-Treasurer, Missouri Dental Board, Albany, Missouri. Personal communication, August 7, 1944.

the State of Missouri met at the Hotel Baltimore, Kansas City, Missouri. Members present: Dr. Chas. A. Brown, president, Dr. T. E. Purcell, vice-president, Dr. Geo. E. Haigh, secretary, Dr. W. A. Roddy and Dr. Jesse Miller.

The meeting was called to order by the president, Dr. Chas. A. Brown, the object of the meeting stated, being the investigation of charges filed concerning the Western Dental College of Kansas City, Missouri. Hon. Samuel Sparrow . . . appeared for the Western Dental College, and A. N. Adams for the State Dental Board.

The Western Dental College . . . announced that they would waive the reading of the charges. All witnesses present were sworn by the secretary, Dr. Geo. E. Haigh, and the Board proceeded to hear testimony . . . The Board heard all the testimony presented and continued the case . . . It was agreed that the Board would notify the Western Dental College of what date it would hear further testimony.

George E. Haigh, Secretary [27]

A period of unexplained inactivity on the part of the Board ensued, as the next hearing on the case was not held until June 26, 1916. In the meanwhile, alumni of the Western Dental College, distressed at the crisis facing the school, decided to intercede on behalf of their alma mater and, if possible, prevent the institution from being closed. Doctor Hugh G. Tanzey, who was president of the Western Dental College alumni association in 1914, called a group of twenty alumni together early in the spring of 1916 to discuss ways and means of saving the school from extinction. Of the twenty individuals, only five—Doctors Hugh G. Tanzey (1879-1948), Roy J. Rinehart (1880-1957), George W. Hillias (1870-1954), Samuel E. Johnston (1857-1922) of Leavenworth, Kansas, and Earl C. Braniger (1880-1948) of Maryville, Missouri,—were interested enough to plan a reorganization of the school. After several meetings of this group, negotiations were entered into with the owners for the acquisition of the Western Dental College, which resulted in its purchase for $20,000.[28]

On June 26, 1916, the Missouri State Board of Dental Examiners convened at the Hotel Baltimore, Kansas City, Missouri, for further deliberations.

The meeting was called to order by the President, Dr. T. E. Purcell, all members of the Board being present. The Western Dental College case was taken up by the Board, and Mr. Samuel Sparrow, the attorney who had represented the Western Dental College, appeared before the Board stating that he no longer represented the school, as it had been sold, and that the parties who now owned the school

[27] Minutes, Missouri State Board of Dental Examiners. April 12, 1915.
[28] *See* footnote 19.

were represented by Mr. [Albert L.] Reeves and Senator [George W.] Humphrey, who together with the members of the Alumni who were present, stated that they purchased the Western Dental College and it was their desire and intention to run a good, clean, reputable institution and asked that they be recognized as such.

The Board after considering all evidence of the previous hearings in this case, and after careful consideration of the case, made the following finding:

In the case of the Western Dental College, the Board having heard all the evidence in the case and the arguments of council, do find that the charges are sustained, but that inasmuch as the College is now under new management the Board recognized the school as a reputable institution and will do all in their power to assist the new management in maintaining a creditable institution.

V. R. McCue, Secretary [29]

This action of the board enabled the new owners to reorganize the school and continue its existence. Hugh G. Tanzey became president, Samuel E. Johnston, dean, Roy J. Rinehart, secretary, George W. Hillias, first vice-president, and Earl C. Braniger, second vice-president.[30] To this group of loyal alumni belongs the honor of saving the Western Dental College from extinction.

The conditions which prevailed at the Western Dental College after the death of Doctor McMillen were not uncommon in the proprietary era of dental education in those schools of private ownership. Prior to 1909, no accrediting agency existed for the regulation of dental schools. The National Association of Dental Examiners, organized in 1883, and the National Association of Dental Faculties, organized in 1884, exerted some influence in attempting to standardize dental education; but it was realized that if the best results were to be obtained a separate agency, devoted solely to that purpose, must be created. It was in 1909 that the Dental Educational Council of America was founded as a regulatory body for dental schools,[31] but unfortunately, wholehearted support of the Council was not forthcoming from all state boards and schools, with the result that "the Council was unable to function effectively until about 1916." [32] Consequently, it is not difficult to understand how irregularities could occur in privately owned dental schools, particularly when pecuniary gain was involved. Even the "affiliation" of some of the privately owned

[29] Minutes, Missouri State Board of Dental Examiners. June 26, 1916.

[30] *Western Dental College Bulletin*, 1916.

[31] Henry L. Banzhaf, History of the Dental Educational Council of America. *Dental Digest*, 1918, *24*: 721.

[32] W. J. Gies, *Dental Education in the United States and Canada*. New York: Carnegie Foundation for the Advancement of Teaching, 1926, p. 102.

dental schools with a university proved to be only a cloak of academic respectability for a continuation of the wretched practices of the proprietary era.

The Western Dental College, for the twenty-nine years of its existence, was privately owned. It had a total of 1,251 graduates and admitted women students on the same basis as men. (In contrast, the Kansas City Dental College never would admit women students.)

The Western Dental College contributed many distinguished men to dentistry, the foremost doubtless being Burton Lee Thorpe (1871-1923), a graduate of the class of 1895. Author, lecturer, educator, historian, and executive, he served dentistry in numerous capacities. He was one of the organizers and the first dean of the Barnes Dental College (1903-1916) of St. Louis. He served as president of the Missouri State Dental Association (1901-1902), and also as president (1909-1910) of the American Dental Association. His contributions to dental history are noteworthy.[88]

[88] *History of Dentistry in Missouri.* Fulton, Mo.: Ovid Bell Press, Inc., 1938, p. 149.

THEORIES OF VISION AND COLOR PERCEPTION OF EMPEDOCLES AND DEMOCRITUS; SOME SIMILARITIES TO THE MODERN APPROACH *

RUDOLPH E. SIEGEL

The famous mathematician Archytas of the fourth century B. C. wrote about the preceding generation of scientists: "Since they passed excellent judgment on the nature of the universe they were also bound to have good judgment on detailed problems." [1] This statement still holds true today. Interesting similarities can be found if we try to correlate some scientific theories of the fifth century B. C. to some modern concepts. The endeavour of these ancient scientists was similar to that of modern scientists. Both tried to reduce the variety of observations to the minimum of factors, the goal of science being simplification. To find some basic scientific concepts behind the philosophical and prescientific terms of the ancients in the fields of vision and color perception will be the purpose of this paper.

I. Theory of Vision

Four assumptions are the foundation of the theory of vision of Empedocles (Sicily, c. 450 B. C.) and connect his views with the general philosophical thought of this time.[2] The most important is the "atomic" concept. This was more extensively worked out by Leucippus and Democritus of Abdera (Thrace, c. 420 B. C.). But Empedocles had already assumed that the basic elements were arranged in a certain order. They were called *stoicheia*.[3] This word is usually translated as "elements," but this translation does not reflect the entire and original meaning. The root of the word is *stoichein*, which means "to arrange in battle order." Diels pointed out that the word *stoichein* referred also to the letters of the

* Read in abbreviated form at the thirty-first annual meeting of the American Association for the History of Medicine, New York, May 22, 1958.

[1] H. Diels–W. Kranz: *Die Fragmente der Vorsokratiker*. 6th ed., Berlin, 1951 (hereinafter referred to as D-K), 47 B 1.

[2] W. Jablonski: Die Theorie des Sehens im griechischen Altertum. *Arch. Gesch. Med.*, 1930, *23*: 306-331.

[3] D-K, 31 A 40 and 43.

alphabet because of their arrangement in rows. The word also was applied to describe the arrangement of seeds in wheat and oats, and even for description of space relationship in astronomical treatises.[4] This interpretation found the approval of Burnet and others.[5]

Thus, a structural configuration was implied in the original concept of primary elements. Empedocles incorporated this concept also into the theory of "emanation."[6] He assumed the passing of some very fine corpuscular stream from the object of vision into the eye of the observer. He did not specify the nature of this emanation in detail. Leucippus and Democritus accepted this theory.

Leucippus wrote: ". . . images of some kind and of appearance similar to the object leave in continuous stream the object of vision and arrive in the eye thus causing visual perception."[7] Democritus specified that the emanation from the object formed a kind of imprint in the air which would be the immediate object of our perception. Theophrastus objected for various reasons to this theory of imprints or replicas. Actually, for the analysis of the concept of sense perception, it could be disregarded since it takes place outside the eye. This strange idea of imprints in the air may have had its origin in the observation of reflections in countries near sea or desert. Occasional occurrence of the so-called fata morgana is the pictorial appearance in the air due to some reflection. It may be independent of actual objects.

Democritus called this imprint, which shapes the space between object and eye, an image. The Greek word for this traveling image is *eidolon* or *deikelon* which means "representation," or "Gestalt."[8] It denotes a replica of an original object which cannot be perceived directly. We may guess that some aspect of this visual process went into the theory of ideas, of "forms," of Plato. It is strange that Plato hardly ever mentions Democritus in his writings, even in those about sense perception.[9]

According to Aristotle's testimony, air seemed not to be essential as the medium of conduction of the visual emanation. He quotes Democritus:

[4] H. Diels: *Elementum*. Leipzig, Teubner, 1899, chapter 7.

[5] J. Burnet: *Early Greek Philosophy*. 4th ed., London, A. & C. Black, 1930. Also K. Freeman: The Presocratic Philosophers. 3rd ed., Oxford, Blackwell, 1953.

[6] Aristotle: *De anima*, 419 a 17; also D-K, 31 B 89.

[7] D-K, 67 A 29.

[8] C. Bailey: *The Greek Anatomists and Epicurus*. Oxford, The Clarendon Press, 1928, chapter 3.

[9] J. I. Beare: *Greek Theories of Elementary Cognition from Alcmaeon to Aristotle*. Oxford, 1906, p. 21.

". . . if space were free of air and moisture, one should be able to see an ant at the vault of the sky." [10]

As opposite to the emanation originating from the object of vision, these scientists assumed another emanation, simultaneous with, or preceding, the act of vision, from the eye to the object. This strange idea started most likely with Empedocles, was supported by Democritus and Plato, and later by the Stoics.[11] It is still allegorically used when we say "to throw a glance" on something. In connection with the evolution of physiological concepts, only the idea of emanation from the object toward the eye is of interest to us. (For more details see Bailey.)[12]

The third assumption which was incorporated into the theory of vision by Empedocles expressed the idea of the four "elements." He declared that these compose all objects of the physical world. This doctrine arranged the four elements according to the size of their ultimate particles. Empedocles considered fire, the finest, as the most penetrating and the most intimately connected with sense perception and thought. Fire, in this respect, cannot be regarded as flame. The eye was, of course, composed of a mixture of the four elements. Fire, according to Empedocles, made up an important part of the interior of the eyeball. Aristotle thought that this apparently erroneous idea arose from the sensation of fire if the eyeball is hit hard from the outside.

Empedocles thought that there was also a considerable amount of water in the inner eye, surrounding the fire. It had been observed that the eye loses the internal fluid, the waterlike corpus vitreum, in case of injury. Democritus described also the heavy, clear fluid of the corpus vitreum without recognizing the lens. We should not assume that tears and the fluid of the anterior chamber were also considered as arising from the same source, since they represented certainly "the water around the eyes" of the ancient authors.

A fourth concept was connected with the behaviour and arrangement of all things in nature: the concept of "the opposites." The idea of opposite qualities had been one of the fundamental patterns of Pythagorean thought. The Pythagoreans spoke only of static qualities of opposites (straight and curved, light and dark, etc.). Alcmeon was the first to introduce the concept of dynamic balances into medicine. He spoke of two components partaking in the same process. Such substances should rather be called "complementary," not opposites. Empedocles generalized

[10] D-K, 68 A 122.
[11] Jablonski, *op. cit.*, p. 309.
[12] Bailey, *op. cit.*

this dynamic concept and introduced it also into astronomy. He spoke of the contrast of repulsion and attraction under the allegorical names of "Love" and "Hate." Empedocles applied the dynamic concept of the equilibrium of two components to the theory of visual perception.

Thus, we have to deal with four fundamental concepts: the idea of the four elements; the concept of their atomic structure and definite arrangement in space; the idea of corpuscular emanation from these elements in the form of a replica, a Gestalt; and finally their behaviour according to opposite, or as we may say, complementary attributes. There is no contradiction between these four concepts. In the framework of this predominantly deductive and prearranged structure of concepts, Empedocles and Democritus were able to express various observations on sense perception and adapt them to their general physical and philosophical theory. In the following we will try to pierce behind the conventional expressions and often poetical allegories of Empedocles. We will try to understand which of the actual observations of Empedocles and Democritus were empirical and correct, and how far their ideas can be related to some basic concepts of vision still in use.

Nowadays, any treatise on perception would start with a description of the anatomy of the perceiving organ. We do not know of any real description of the eye by Empedocles or his contemporaries. As already mentioned, they thought that the interior of the eyeball was predominantly made up of fire and water, whereas the outer membranes and other structures of the eye consisted of all four elements [13] in various combinations. Empedocles called also the incoming light rays "fire," since, because "of their subtility, they could easily pass through the structures of the eyeball." We have to recognize that the term "fire" represents here two things: the emanation corresponding to our light rays and one constituent of the receptive elements inside the eyeball itself.[14] The receptive parts of the eye were called pores (*poroi* in Greek). This means "fine channels." as does our word "pores." We would call them retinal elements. We cannot be sure that Empedocles already differentiated these receptive media of the eye from its conductive part which leads to the brain. Alcmeon of Croton, who lived before Empedocles, had already described the optic nerves and their crossings. Alcmeon assumed that the interior of the eyeball contained fire as irritable agent, and that the optic nerves

[13] Theophrastus: *On the Senses.* Text and translation in G. M. Stratton: *Theophrastus and the Greek Physiological Psychology before Aristotle.* London, Allen and Unwin, 1917.

[14] Beare, *op. cit.*

conduct the light perception into the brain. But Empedocles disregarded Alcmeon's discovery of the brain as the central nervous organ and still maintained that the seat of thought was in the blood around the heart. Nevertheless, Empedocles must have assumed also some kind of conduction of light through the cornea into the eyeball, and the transmission of this perception into the interior of the body.

Based on such rudimentary anatomical knowledge, the concept of Empedocles was that two structures which were made up of fire and water received the incoming light rays. The assumption of two receptive elements in the eye was probably based on the observation of certain visual patterns, rather than on anatomical considerations. The pores of the eyeball were, according to Empedocles, arranged alternatingly by the two elements. But he did not give any hint of the exact anatomical location in the eye. It is worth while to quote the text as related by Theophrastus who is one of our main sources for the theories of both Empedocles and Democritus:

> The pores of the eye are arranged alternatingly as those of fire and water. By passage through the fiery pores we perceive the white objects, whereas through the watery we perceive the black objects. Each sense perception has to fit into its end organ. Colors are carried by emanation to visual perception.[15]

According to Empedocles, all sense organs act in a similar way and perception occurs because of the adaptation of the particular pores of the end organ to the incoming stimulus. For this reason one sense organ cannot discern the stimulus of the others because the passages of some organs are too wide, of others too narrow, for the incoming stimulus.[16] An obvious conclusion from this text is that Empedocles anticipated in some way the idea of sense specificity. He declared that a sense organ can only react to a specific agent to which it is structurally adapted. This concept is summarized in the formula: "like to like."[17]

More details of such a mechanism of sense perception are given by Aristotle:

> Some believe that every organ is affected when an external and most preponderant factor enters through the pores. And they say that this is the mode of our hearing and seeing and all the other sense perceptions. Vision takes place through air and water and the transparent media of the eye, and through pores invisible due to their smallness but arranged in a certain order, very close to each other. The more

[15] Theophrastus, *op. cit.*, 7.
[16] *Ibid.*
[17] Freeman, *op. cit.*, p. 197.

transparency they exhibit, the closer they are together. Some writers, like Empedocles, distinguish not only the active and recipient factors, but also declare that contact takes place where the perceiving pores are of the same shape as the incoming agent.[18]

This idea was elaborated further by Democritus. According to his detailed descriptions, perception takes place only if the receptive organ has a geometrical shape similar to that of the particles approaching it from the object of vision.[19] Thus, sense specificity was reduced to a geometrical structural specificity of the receiving organ. This theory was accepted and considered valid even as late as the time of Plutarch, who said that "colors are that which fits in the pores of the eye." [20]

Some statements of Empedocles suggest that his idea of sense specificity was neither entirely deductive nor merely speculative, but based upon observations. He connected the idea of sense specificity with the assumption of only two receptive structures by observing the differences between day and night vision, which is the same as dark adaptation.

The construction of the eyes, which are composed of these elements, is not always equal. In some eyes the fiery factor is more centrally, in others more peripherally, located. Therefore, some animals see better during the day, others during the night.[21]

In Empedocles' view, the two elements balance each other out, and the prevalence of one or the other mediates more or less day or night vision, according to their state of balance. Best vision is present when both elements are in equilibrium.[22]

We definitely know that the human eye carries more cones for the perception of colors (day vision) in the center of the retina, whereas the perception for shades between black and white (night vision) is better in the peripheral areas of the retina where the rods prevail. This corresponds to the text of Theophrastus who wrote that the centrally located fire corresponds to better performance of the eye in daylight. This idea is in correspondence with modern histological findings.

Comparative physiology also knows differences in some domesticated animals, (e. g. the cock and pigeon have fewer rods and therefore less night vision).[23] This correlates the modern concepts to the observations

[18] D-K, 31 A 87.
[19] Beare, *op. cit.*, p. 24.
[20] *Ibid.*, p. 21, referring to Plutarch: Epit, 1, 15, 3.
[21] Theophrastus, *op. cit.*, 8.
[22] *Ibid.*
[23] L. Landois–R. Rosemann: *Lehrbuch der Physiologie des Menschen.* Berlin, 1919, vol. 2, p. 797.

of Empedocles as was just mentioned. From our point of view, the ideas of Empedocles seem to reveal a deep insight or even anticipation of later developments. Besides the recognition of the structural differences, modern research explains visual perception also by the balance of chemical substances. Empedocles could never have made observations of the minute structures of the eye to prove his concept. But it appears that the idea of a dynamic balance of complementary substances represents a basic concept in medical research. Empedocles suggested, besides the existence of two receptive substances, their dynamic equilibrium also:

> Even the animals which have fire in excess are dim sighted during the day since the fire within the eye has been further increased by the daylight; this covers and occupies the passages of water. The same thing happens by night to those animals which have water in excess, because fire is now overtaken by water.[24]

The concept of balances is further and more clearly stated in the continuation of the text:

> The eye reveals the best mixture and the most advantageous blending if it is composed of both constituents in equal measure.

We know that light decomposes the compound of the visual purple which is essential to its perception. It changes the dynamic chemical balance. This is the physio-chemical basis of what we call dark adaptation. The visual purple, the photo-sensitive compound of the retina, can be associated with different proteins, thus performing either color or black-white perception.[25] Excessive strain changes the balance of such temporarily formed compounds and makes perception difficult.

Furthermore, Empedocles must have observed that dark pigmented eyes have better vision during the bright daylight, but eyes with a blue iris have better performance at night. The color of these eyes is denoted with the Greek word *glaukos*, which is usually translated as "gleaming," (in modern Greek it means a shiny blue), and in this sense it has been definitely used by the ancient authors. We know that blue eyes have less pigment. It is known that the less pigment the eye contains, the more its performance during the day is impaired. Other authors (Jablonski,[26] Magnus[27]) support this conclusion. According to Theophrastus' book, Diogenes of Apollonia made the same observation:

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[24] Theophrastus, *op. cit.*, 8.

[25] "Theory of vision," *Encyclopedia Americana*, 1955, vol. 7, p. 310.

[26] Jablonski, *op. cit.*, p. 314.

[27] H. Magnus: *Die geschichtliche Entwickelung des Farbensinnes.* Leipzig, Veit, 1877, p. 30.

Contrasting colors become best visible: black eyed persons see better during the day and perceive better brilliant objects, whereas persons of opposite qualifications have better vision at night.[28]

Thus Empedocles has anticipated with scanty observations and more intuition three principal ideas of the theory of vision: specific end-organs, different structural characteristics of different areas of the retina, and last not least, some kind of equilibrium of two complementary constituents. He could only guess at these ideas in view of the lack of anatomical knowledge or chemical concepts. His thoughts were based upon the theory of corpuscular emanation in order to explain the transmission of sense perception. This concept was extended to the explanation of sense perception other than the visual.[29]

II. Theory of Color Perception

So far we have spoken only about visual perception in general and not about specific colors. Many chapters of Theophrastus' text are concerned with what we would call psychology of color perception; other sources supplement his description to some extent. It seems that the theory of color perception of Empedocles and Democritus arose from an empirical study of the optical effect of color mixtures.

For the ancient Greeks the qualities of black and white were actual colors and not only shades of light of different intensity. The fact that white could be broken down into the manifold spectral colors had not yet been discovered. Aristotle regarded all colors as shades between black and white.[30] This was due to the misconception that the idea of contrarieties could and should be applied to all types of sense perception. It also arose from the fact that before Aristotle the aspect of color as such was not yet separated from its carrier. Colors and dyes were considered as being one and the same. It did not occur to pre-Aristotle Greeks that in the rainbow the uniform white light of the sun was separated into colors. Nevertheless Xenophanes (530 B. C.) had already recognized only three colors as principal colors of the rainbow: purple, crimson-red, and yellow.[31]

Empedocles assumed, in analogy to the four elements, a minimum of four colors and tried to explain the various color impressions from their

[28] Theophrastus, *op. cit.*, 42.
[29] *Ibid.*, 7 ff.
[30] Beare, *op. cit.*
[31] D-K, 31 B 32.

mixture in different proportions. Democritus followed his lead and declared: "There are four basic colors." [82] These four colors were black, white, red, and yellow. Democritus thought that all color shades could be obtained from the mixing of these four. It can be assumed that he arrived at his theory by experimentation with dyes and by mixing paints. Since the text of Theophrastus indicates to some extent how Democritus obtained these combinations, I tried to reproduce these results with simple color mixtures.

In order to comprehend the practice of the ancients we have to realize that they used only a limited number of dyes for painting. Therefore it should not be difficult to duplicate their practices. Democritus used powdered marble or pulverized sea-shells for white. An earth color, ochre, served as yellow. A mercury compound, vermilion, was usually the source of red, although there were other red shades available. They were produced by the heating of certain earth colors of iron content. Reddish burnt earth colors, still used today, go back to antiquity. They are known under the names of burnt sienna, Venetian red, and others. Black was charred ivory or bone. Also soot was, and is still being used. Some of the actual dyes have been found in graves of great antiquity. More is known from literary sources.[83] Mixtures were tried by me according to the text of Theophrastus' book, *De Sensu*.[84] The results seem to disprove those authors who assumed that Democritus was guided by abstract reasoning and not by actual experimentation.[85]

A specific problem arose in choosing the demanded shades of black which the text often recommended in combinations for which we would employ a deep blue.[86] The identification of black and blue may have resulted from the bluish tinge of the shadows in Mediterranean countries.[87] Owing to contrast, these shadows often even assume a deep violet tinge. As proof for this opinion Plato's words may be quoted: "Halourgon (violet) is obtained by mixing white, red, and black." [88] Any painter will know that if violet was to be obtained in such a way, the color described by Plato as black must have been definitely of a blue tinge.

[82] Theophrastus, *op. cit.*, 73.
[83] H. Michell: *The Economics of Ancient Greece*. New York, Macmillan, 1940, p. 189.
[84] Theophrastus, *op. cit.*, 73 ff.
[85] Bailey, *op. cit.*, p. 169; also, Theophrastus, *op. cit.*, p. 199, note 182.
[86] Theophrastus, *ibid.*
[87] More historical and literary comments on this observation are contained in Magnus, *op. cit.*, p. 41, who follows the synonymous use of blue and dark even into the Roman texts, but erroneously attributes it to lack of development of color sense.
[88] Beare, *op. cit.*, p. 53.

The text says further: "If black is added in greater amount a dark violet is obtained," and "when some white is added to intense black a deep blue is produced."

We know that if white is added to our black only a gray shade can be obtained. That the term "black" had such a double meaning for the Greeks can also be derived from another passage of Plato where he says that grey can be obtained from the mixture of white and black. Plato discourages the investigation of these mixtures by experimentation, since it would only "show the ignorance due to the difference between human and divine nature . . . since only god has knowledge and power to blend the many into one." [89] If Plato's predecessors had not been experimenting, and if they had not so freely expressed their belief in materialistic explanations, Plato would not have needed to revert to mysticism, advocate the abandonment of experimentation, and urge secrecy.

We read in Theophrastus' text that Democritus indicated how to obtain a "golden tinge" and "copper color." These two colors could actually be obtained by the mixture of vermilion or burnt Siena with some white. An addition of "a little green," as the text suggests, makes the color really "more beautiful." By using a modern brand of red, like cadmium red, only an uninteresting pink shade could be obtained, instead of the ancient color.

The color called *isatin* in Greek, "woad-hue" in English, is a kind of greenish, dark-blue which, against expectations, could be obtained by the mixture of ivory, black and yellow ochre. The production of a dark-blue indigo from the so-called black by addition of some yellow and red ran at first into difficulties. Likewise, "leek-green" (*parsinon* in Greek) could not be obtained by mixing black and ochre. But these two colors could easily be produced if, instead of the ivory-black, some kind of deep blue was used.

There is a passage in the text that says that "red and white give a yellow tinge and not black (!)" The mentioning of black makes little sense. But in fact, burnt Siena as red, added to white, makes in proper dilution a fine yellow, as the text prescribes. But it cannot be obtained by using a modern red. The mentioning of black can only be understood as an error in the transmitted text. Also, some other passages of the manuscripts seem to make very little sense. The indication of some of the mixtures supposedly used by Democritus must have been distorted or mutilated by the copyists. For instance, brown which one can easily

[89] *Ibid.*

produce by mixing some real black with red can never be obtained from yellow and blue as the text suggests.

All in all, it appears therefore possible to obtain most of the known shades of colors, or at least those used by the ancient painters, by combinations of four basic dyes: red, yellow, white, and blue-black. Nowadays, physiologists would speak not of four, but of only three colors, since in view of our theoretical knowledge of spectral colors, white is not considered a color any more, although it is sold as a dye or paint. We may therefore say, that the four basic colors of the ancient Greeks were only three according to our terminology: red, yellow, and blue-black. It will now be possible to draw a comparison of modern concepts of color perception in relation to these three colors.

Instead of mixing dyestuffs the modern physicist combines spectral colors. The best-known theory which postulates a three-color scheme was pronounced by Thomas Young (1803) and Hermann von Helmholtz (1832). They said that most color shades can be obtained by the combination of various amounts of three basic colors: red, green, and violet. The only difference between these and Democritus' colors is that here green takes the place of yellow. But there is a large amount of yellow in any green besides the other basic compound, blue. We know that the theory of Young-Helmholtz is not an explanation of the physiological process in the retina. It is, as the ancient theory was, only a practical rule to bring order into the multitude of color combinations. The fact that newer color combinations have replaced this theory in its application to industry, or to the theory of color perception, does not detract from its merit. To our minds an astonishing similarity exists between the four-color concept of the ancient Greeks and the modern three-color theory of Young-Helmholtz. The ancient and the modern schemes arose from the endeavour of the scientists to reduce their actual observations to the most simple components. It proved to be impossible to assume fewer than three basic colors: red, yellow-green and blue-violet. Helmholtz arrived at this simplification on the basis of his advanced knowledge of spectral colors. Democritus based his theory on the assumed arrangement of a small variety of hypothetical atoms. Both physical interpretations served as satisfactory explanations of the psychological phenomena of color perception. This leads us to the problem of the connection between the physical events of sensation and the comprehending mind in the opinion of these philosophers.

III. Perception and Reality

In agreement with the assumed atomic structure of physical bodies, the soul also was considered as a very fine corpuscular agent. Dispersed throughout the body, it reacts upon the "impressions" of the incoming particles. According to Democritus, the emanation which causes the image of the cornea penetrated through this transparent membrane into the eye. In its further course this image is carried to the central seat of perception and reasoning.

Although Alcmeon had previously discovered and clearly stated that he considered the brain the center of perceptual function, Empedocles did not accept this idea. But Democritus and the medical writers of Cos followed Alcmeon's lead. At least the reasoning part of the soul was projected into the brain, whereas the other parts of the soul were believed to be scattered throughout the body.[40] Now whatever the seat of the soul was supposed to be, by this assumption of an atomic structure of soul and body the causal chain appeared to be closed. By considering the soul and the organs of reasoning to be analogous in atomic structure, a mechanical connection between the object and subject of perception was constructed. The gap between physiological and psychological events seemed to be bridged. This result seemed to justify the atomic theory as an explanation of the interaction between body and soul.

But Democritus was still quite aware of the fundamental difference between self-consciousness, subjective sense impressions and their objective physical cause. In any event, he must have doubted that he had found the ultimate solution of these age-old problems. He wrote:[41] "In general, the (atomic) shape concerns only itself, whereas sweetness or whatever we perceive, exists only in relation to something or in something else." Yet the problem of self-consciousness interested him less than the interaction between object and subject. Democritus considered colors or other qualities of sense perception (such as sweetness, bitterness, odours, etc.) only as subjective phenomena. He declared that the so-called qualities of colors were merely conventions; that sense impression arose from an undetermined hypothetical reality: the atoms and their spatial arrangement.[42] Democritus gives very detailed descriptions of how the existence of the various shapes of the different atoms could explain the different impressions which they cause in the eye. The well known and rather

[40] D-K, 68 A 105.
[41] Theophrastus, *op. cit.*, 69.
[42] D-K, 68 A 125 and A 9.

deductive, speculative aspect of his color theory has been sufficiently discussed in the literature by many authors.[43] Democritus' text gives an almost geometrical, or as we may say, crystallographic description of the hypothetical structure of different substances according to their colors. The description was not entirely based on observation for which the technical methods were still missing. Yet, the origin of the whole theory may have been the observation of structural differences such as smoothness, brittleness, and fragility, of dyestuffs and minerals, the behaviour of such substances under the influence of heat etc. In fact, such speculations prove that Democritus was searching for an objective basis of color perception. This does not contradict the fact that he denied to color as such an objective quality; but he described and defined the perceived color solely as convention. Democritus never questioned the real existence of atoms as the physical basis of sense impressions. He only declared that the nature of this reality will be unknown forever. He could not have anticipated that 2500 years later an objective measure would be found for colors in the wave length of light rays and that the structure of light-emitting atoms would become popular knowledge. Only recently has it become possible to describe the physical nature of colors independently from psychological definitions of colors. How prophetic were the words of Democritus:

> This discussion reveals that we do not know anything about the true reality; but everybody's belief (opinion) is due to the incoming stream (of atoms).[44]

His book, which carried the title *About the Different Arrangement* (i. e. of the atoms) *and the Concepts of Forms*, has been lost. It may be of interest to mention that the word "arrangement" is used here as the translation of the Greek word *rhythmos*, which in relationship to the color-producing electron-rings of atoms has a deeper meaning to us than the author could ever have anticipated. Also lost are his other books: *About the Mind*, *Perception*, and *Colors*, only the titles of which are known to us.

The application of the atomic principles to the theory of knowledge presents in striking simplicity a bridge between the objective unknown world of the atoms and the subjective phenomena of sense perception. All sense perception takes effect, according to the Greek philosophers, by contact. The Greek word for this is *haptein*. This should not be translated in the narrow sense of "touching" but in the more general concept

[43] E. g., J. Burnet, C. Bailey, G. M. Stratton, et al.
[44] D-K, 68 B 7.

of "contact." Touch applies only to the perception of the nervous end-organs of skin and mucosa. "Contact" is also the basis of hearing and of visual perception, especially in the ancient and modern sense of visual "emanation." Many statements of Democritus and similar statements of the Sceptic school prove the enormous influence of Democritus on the following generations of Greek and Roman philosophers. Their ideas suggest an influence also on the attitude of the English school of the 17th and 18th centuries..[45] In many details the parallelism even to modern epistemiology and phenomenology is rather striking, but its discussion is beyond the frame of this paper.

The color theory of Democritus did not lead to further clarification of the concepts of vision. Plato considered white and black to be opposites.[46] Aristotle tried to derive all colors from their combination.[47] Aristotle defined the colors as variable gradations of these two opposites.[48] This error was due to the confusion of luminosity and color. Aristotle also denied the emission of light and refused to recognize that it takes time for light to travel, although Empedocles had already discovered that the propagation of light is not instantaneous.[49]

Basing his views on the misconception of opposites concerning colors and on the idea of contraries, Theophrastus [50] also criticizes Democritus "because he does not represent the primary colors as opposites, such opposites being assumed by all writers." As we understand it today, it is the merit and not the mistake of Democritus that he considered colors as qualities related to the hypothetical structures of the atoms. It is to his credit that he did not deduce a theory of colors according to some preconceived idea of contrarieties from an assumed original pair of opposites, such as black and white. This would have been fitting facts into some metaphysical speculation, in contradiction to all experience of the painter's trade and common sense.

Whether the study of the ancient philosophers and their pattern of thinking has influenced the founders of modern physiology is a different question. Only detailed biographical study, if such were possible, might shed some light on the motives which led to recent discoveries. Similar

[45] S. Sambursky: *The Physical World of the Greeks.* London, Routledge and Paul, 1956, p. 118.
[46] Beare, *op. cit.*, p. 49.
[47] Bailey, *op. cit.*
[48] Beare, *op. cit.*, p. 69.
[49] D-K, 31 A 57.
[50] Beare, *op. cit.*, p. 36.

correspondence in other fields of science and medicine can be proved by the study of the observations and theories of the ancients. Although these features are hidden amongst many obsolete ideas, further advances were only possible through experimental proof of the intuitive concepts. That Democritus was conscious of the predominantly theoretical nature of his discussions is revealed by one of the few aphorisms which have reached us: "I would rather find one single proof than win the throne of the King of Persia." [81]

[81] D-K, 68 B 118.

THE CHANGING IDEOLOGY OF HEALTH MUSEUMS AND HEALTH FAIRS SINCE 1850 *

BRUNO GEBHARD

Health museums and health fairs in the U. S.A. have the Sanitary Institutes of England and the Hygiene Exhibitions of Germany as their grandparents. Preventive medicine and public health education can rightly be called their parents. Health museums, or their forerunners, the hygiene museums of the 19th century, have, like most museums, an individual as the founder, and their subsistence is derived usually from the support of interested lay individuals or lay groups, before the professionals or governmental agencies think the enterprise worth their support.

There is an impressive list of physicians as founders of museums, from the venerable Dr. Hans Sloane, British Museum (1753), to the Drs. Alexander Baron and Peter Fayssoux, co-founders of the oldest museum in U. S. A., at Charles-Town, South Carolina (1773), and Dr. Daniel Drake, founder of the Western Museum (meaning west of the Alleghenies) in Cincinnati (1820)[1] which closed in 1835. It never occurred to these men to include materia medica, or items of hygienic interest, in their museums' collection.

The Charles-Town Museum was the only one which later came in contact with medicine, but more by default than design. In 1829, its collections were deposited in the Medical College, as shown in an advertisement which appeared in 1846:

> The Student of Anatomy and Natural History, has facilities afforded him, which are equalled by few, and surpassed by no similar institution of our country. In addition to the Anatomical preparations and Chemical Apparatus received last year from Europe, the Chalmers-Street Museum, containing a large collection of Minerals, Shells, Birds, etc., has been removed to the college, where it will permanently remain.[2]

Our starting point is the year 1851, the year of the Great Exhibition in London. There was little to see so far as medicine was concerned.

* Read at the thirty-first annual meeting of the American Association for the History of Medicine, New York, May 22, 1958.

[1] Bruno Gebhard. From medicine show to health museum. *Ciba Symposia*, 1947, *8*, 578.

[2] American Association of Museums. *Proceedings*, 1915, *9*, 60.

There was nothing representing the great sanitary movement of those days. Of the 742 items listed in Class 10, " Philosophical, Musical, Horological and Surgical Instruments," not even three dozen were surgical; there were, for instance, a medico-chirurgical ambulance, a medical walking staff containing instruments and medicines, artificial teeth carved from hippopotamus ivory, and a duplicate stethoscope made of gutta-percha as a real novelty.[3] The " authentic voice of the new hygiene " was demonstrated by a " model lodging house " to accommodate four families, presented by the " Society for Improving the Dwellings of the Labouring Classes " but paid for by the Prince Consort, the President of the Society.[4]

American contributions were meager and poor. Early models of sewing machines competed successfully with an air-supported coffin intended to preserve the dead from putrefaction. The American section showed the horn of a unicorn, a residue from the medieval museum, a prize piece of their magical collections, treasured as a preservative against poisoning, or as inducive of perspiration against fever, whichever the situation demanded.

The advertising pages of the *Official Catalogue* give a good cross-section of the favored patent medicines of those days, mainly fluid magnesia, pulmonic and antibilious wafers, and herbal embrocations for whooping cough. An advertisement with a beautiful woodcut asks for voluntary contributions to the Seamen's Hospital on board the " Dreadnought." Madame Tussaud and Sons invite visitors to see her Historical Gallery, celebrating its 50th anniversary.

One should not expect too much in our field from the Great Exhibition. It was, after all, devoted " to the industry of all nations," but even the sanitary industry was conspicuous by its absence. It made its full showing at the first International Hygiene Exposition in Brussels in 1875 and in the first Museum of Hygiene, named after Dr. E. A. Parkes, formed in London in 1877.

Edmund A. Parkes, M. D. (1819-1876), was the first Professor of Hygiene at the Military School at Chatham and author of *A Manual of Practical Hygiene Prepared Especially for Use in the Medical Service of the Army*. Among the first vice-presidents of the Museum was Florence Nightingale, one of its most ardent supporters. The Royal Sanitary Institute, founded in 1876, took over the management of the Museum. In a

[3] *Official Catalogue of the Great Exhibition.* London: W. Clowes & Sons, 1851, pp. 60-74.

[4] Yvonne Ffrench. *The Great Exhibition.* London: The Harvill Press, 1950, pp. 219-21.

charming New Year's letter, December 31, 1884, Florence Nightingale wrote from her home, 10 South Street, Park Lane, West, to Mr. E. White Wallis, at that time Secretary of the Institute:

"Dear Sir:

I wish a Happy New Year and many of them to your valuable Parkes Museum and beg to enclose a trifling sum which I wish I could multiply one hundred fold.

I was sorry that owing to business and illness I was too late in sending in my name to Captain Galton for the petition to the Healtheries." [5]

Parkes Museum for many decades consisted mainly of a great series of models dealing with plumbing, drainage, and sewage disposal. It was more a memorial to Sir John "Going to the John" Harrington's invention of 1596.

Health education in England in the second half of the 19th century was a part of the many attempts at social improvement. It had a more or less moralistic overtone, and it developed with little contact with organized medicine. The program for the 28th Annual Meeting of the National Association for the Promotion of Social Science in 1884, especially that of its Health Department section, includes as many items concerned with medical care, as with sanitary legislation. There was a great debate whether the reduction of mortality in children under 15 years was a result of the Education Acts in 1870 and 1875, or was due to the enactment of sanitary legislation in those two years.[6]

Public museums as "an expression of the 18th Century spirit of enlightenment which generated enthusiasm for equality of opportunity in learning" [7] had become numerous in England by reason of an Act of Parliament of 1845 whereby "Town Councils of boroughs with a population of 10,000 were allowed to levy a small rate for the establishment of Museums of Arts or Science for the education and amusement of their inhabitants." [8]

Science for everyone became the slogan—but the medical sciences were usually thought of as the prerogative of the medical profession; nevertheless, popular hygiene exhibition had a field day. In 1884, "going to the Healtheries" was the pastime of 4,000,000 Britishers who visited the

[5] *Pamphlet of The Royal Society of Health.* London, July 1956, p. 7. The Lady with the Lamp was referring to the International Health Exposition of that year, held on the same grounds where, a year before, a very popular fishery exhibit took place which was commonly referred to as The Fisheries."

[6] *Brit. M. J.*, 1884, *2*, 582-83.

[7] Alma S. Wittlin. The Museum. London: Routledge & Keagan Paul, 1949, p. 133.

[8] David Murray. *Museums.* Glasgow, 1904, Vol. I, p. 267.

International Health Exposition in London on weekdays from May to October, the exhibition grounds being closed on Sundays. Ernest Hart, Chairman of the National Health Society, gave a critical lecture [9] after the close of the Exhibition, praising an enormous section on foodstuffs which he thought had been successful—health in relation to habitation, food, and dress, having been the main theme. He was also proud of the erection of sanitary and unsanitary homes in full scale, and especially of the first installation of what was called alternately " The Health Laboratories " or " The Biological Laboratories," demonstrating the new science of bacteriology. Another laboratory was run by Francis Galton to demonstrate how progress in individual growth and development, especially in children, can be measured—a forerunner of our annual health examinations. John Shaw Billings was a visitor at the Exhibition and praised it highly.[10] The Health Exhibition came in for considerable criticism, especially for its poor physical arrangement, and the teasing question went around in London, " Where is the health in the health exhibition? "—" Outside in the gardens! " A 19 volume handbook was published about all the affairs of the Exhibition.[11]

The 1884 London Exhibition had taken many of its popular features from one held the previous year at Berlin, the " Allgemeine Deutsche Ausstellung fuer Hygiene und Rettungswesen," where Robert Koch demonstrated, personally, his epochal discoveries, but where the main emphasis was on the physical and chemical conditions of air, water, and soil, in relation to health and disease. The Munich School of Pettenkofer was still dominant. Dr. Villaret,[12] correspondent for the *Berliner Klinische Wochenschrift*, stated that the exposition made a great contribution in making clearer to the educated laity the still dark concept of hygiene (Der Begriff . . . . . war dem gebildeten Laienpublikum bisher ein sehr dunkler.)

Between 1890 and 1915, especially in the United States, came what Haven Emerson has referred to as " the change from the authority of sanitary law to persistent persuasiveness of popular health education." [13] One of the great milestones in this movement was the International Hygiene Exhibition in Dresden, in 1911, with the triple theme, " Der Mensch," " Volkskrankheiten " (Infectious Diseases), and a real innova-

[9] *Brit. M. J.*, 1884, *2*, 1115-22.

[10] John S. Billings. On medical museums. *The Medical News*, 1888, *53*, 309-16.

[11] *The Health Exhibition Literature.* London: Wm. Clowes & Sons, 1884, 19 vols.

[12] *Berl. klin. Wchnschr.*, 1883, *20*, 322-23, 461-63, 509-12, 799-800; *21*, 14-15, 46-48, 78-79.

[13] *The Epidemiology of Health.* New York, 1953, p. 165.

tion, a " Historical Section." The last one, with Karl Sudhoff as chief, had 20,394 objects, very handsomely displayed in 57 rooms. The catalogue of this section (953 pages) has become a collector's item. Sudhoff's programmatic " Notes for the Contributors to the Historical Section," both flamboyant and precise, could serve even today as a good working principle for any museum of historical medicine.[14] Sudhoff had banned such literary matters as manuscripts and books. Plastic objects and specially made up models by the hundreds constituted the main bulk of the display. It was not yet " the historical museum of the healing art " which he postulated in 1901, but it was more than the usual instrument collection, and it could be rightly called in Sudhoff's words, " an institute for public education of the noblest sort." [15]

Germany's leading men of medicine and hygiene were the heads of the different Exhibition departments. Professor Spalteholz supervised the making of many three-dimensional models and showed, for the first time, his transparent specimens. A battery of 100 microscopes gave visitors a chance to see for themselves what germs looked like. The human organism was shown in its wonderfully integrated action in a special section, " Der Mensch als Kunstwerk." An American visitor, Henry G. Beyer, M. D., Medical Director of the U. S. Navy, described the Exhibition: " As an organized endeavor to prevent sickness and prolong human life, to project the living laws of health and happiness into the minds, the hearts and the very homes of people, it certainly surpassed anything of the kind in the whole history of hygiene and sanitation." [16] He also reports with a " humiliating blush the shame," the absence of an American pavilion. " We had no contributions to offer for this most Christian endeavor to raise the hygiene standards among the nations of the world."

The Deutsches Hygiene Museum in Dresden has since become the leader of education in human biology; its plastic life-size figures, known as " Transparent Man " and first shown at the 2nd International Hygiene Exposition in Dresden 1930-31, have become symbols for health museums in many parts of the world. This Exhibition included also, for the first time, two mental health exhibits under the title " *Seelische Hygiene*," and another one on " The Nervous Man."

[14] International Hygiene Exhibition, Notes for contributors to the Historical Section (Author's collection).

[15] Karl Sudhoff and Fielding H. Garrison. *Essays in the History of Medicine.* New York: Medical Life Press, 1926, pp. 321-39.

[16] Henry G. Beyer. The " Internationale Hygiene Ausstellung, Dresden, 1911." *Mil. Surgeon*, 1912, *30*, 125-62.

The Victorian age lingered longer here than in Europe. Public display of matters dealing with the body and physical health were frowned upon. Both the Philadelphia Centennial Exposition of 1876 and the World's Columbian Exposition in 1893 had little to show in the field of medicine or hygiene. The Department of Liberal Arts at the Chicago Fair had a "Bureau of Hygiene and Sanitation." The official historiographer of the Exposition did not think much of it, referring to it with only two lines: "The subject had been exploited in London in an exhibit for which the anomalous word 'The Healtheries' had been coined." [17] In contrast to this, 80 pages were devoted to speeches given at the "Congress of Evolution" which took place at the Fair grounds.

It took forty years until, again at Chicago, representable Medical Science exhibits had a prominent place (Century of Progress 1933-34). The late Eben J. Carey, M. D. had master-minded the medical exhibits, and his being the Dean of Marquette University School of Medicine helped to make the exhibits acceptable to all visitors.

The New York World's Fair in 1939-40 went a step further in presenting, for the first time, three-dimensional models of human reproduction, including those showing the actual birth process. Robert Latou Dickinson (1861-1950) was the originator of this collection which is now in the proud possession of the Cleveland Health Museum.

Exhibitions have been trailblazers for many public health activities, such as the establishment of well-baby clinics, particularly milk sanitation, and in establishing national voluntary health agencies, such as the National Tuberculosis Association (1904) and those dealing with mental hygiene and social diseases. Large exhibitions on tuberculosis were held in Washington and New York, and, in the form of small traveling exhibits, visited many centers in U. S. A. Today we refer to them as "horror exhibits," but the stately American Museum of Natural History opened its door to them in 1908 and one-half million visitors came to see them. The same Museum was the first one to install, in 1912, "Public health exhibits" planned by Dr. C.-E. A. Winslow. The exhibition really did not portray the current thinking on public health and was limited to models on water supply, disposal of municipal wastes, and insect-borne diseases. The exhibitions were dismantled early in 1940, and the Museum is presently engaged in developing a Hall of Biology of Man.

Washington has seen all kinds of medical museums and public health

[17] Rossiter Johnson. *A History of the World's Columbian Exposition.* New York, 1897, Vol. 2, p. 274.

exhibits. Intended primarily for professional education, the venerable Armed Forces Medical Museum, founded in 1862, became a public museum by accident. Being located in Ford's Theater, the scene of the assassination of President Lincoln, visitors to the theater had to pass through the collections of the Medical Museum. How quickly the subject matter in public health and hygiene changes in one generation's lifetime can be seen at the Smithsonian Institution. In 1924, health exhibits, prepared under the leadership of James A. Tobey as Chairman [18] of the "Committee on Exhibits Showing Changes in Sanitary Science," were opened to the public. Thirty years later they were completely outdated, and a new Hall of Health was opened in November 1957,[19] with the theme "Through the ages, man's knowledge of his body."

The professional organizations, mainly the American Medical Association and the American Public Health Association, have a remarkable record in originating temporary health exhibits, and some have been permanently installed, as at the Museum of Science and Industry in Chicago. But we must agree with Wilson G. Smillie that "the permanent public health museum has never secured an outstanding place in America as a broad health education measure." [20] Since he mentions the Cleveland Health Museum as the chief exception, some explanation might be in order. Incorporated in 1936 jointly by the Health Council, representing the laity, and the Academy of Medicine of Cleveland, it opened in 1940. The Museum's activities are supported at present by a dues-paying membership of 4,800 people, of whom two-thirds represent the general public.[21, 22]

Health museums of more recent origin are in Dallas (1946), and in Philadelphia as an integral part of the Lankenau Hospital (1953), giving a real opportunity for patient education. The youngest one opened recently at Hinsdale in suburban Chicago (1958), housed in a doctors' office building and supported by the Kettering Family Foundation.[23]

Revival of Health Fairs on a local basis has taken place in many cities

[18] Personal communication. G. B. Griffenhagen, Smithsonian Institution.

[19] *Bull. Hist. Med.*, 1958, *32*, 80-81.

[20] Wilson G. Smillie. *Public Health: Its Promise for the Future*. New York: Macmillan, 1955, p. 399.

[21] The Cleveland Health Museum, past, present, and future. *Bulletin of the Academy of Medicine of Cleveland*, February 1955, p. 6.

[22] Bruno Gebhard and Winfield G. Doyle. Health Museum at work. *J. School Health*, 1958, *28*, 79-87.

[23] Taking the health message to the public. Editorial, *J. A. M. A.*, 1958, *167*, 72-73.

since the end of World War II. Life demonstrations, blood testing, mass screening of apparently healthy people from children to old age, are fostered as visitors' participation items. The National Health Council and the U. S. Junior Chamber of Commerce are acting as sponsors for these Health Fairs.

Ozzie G. Simmons, in " Implications of Social Class for Public Health," has called attention to the shift from public health education directed to the lower class, to concentration on the new mass diseases, such as the cardiovascular diseases, which have excited great public interest among our higher status group.[24]

The widespread interest of the American public in psychiatric and mental health, in the behavioral sciences, and especially in dynamic psychology, so far as they concern motivation and behavior patterns in health and disease, has only occasionally found its visual form in health education practice. Medical historians of fifty years hence might have the time of their lives in unscrambling the present kaleidoscopic picture as presented daily in movie shows and on the television screen.

[24] *Human Organization*, 1957, *13*, no. 3, 7-10.

A SIXTEENTH CENTURY TRACHEOSTOMY?

C. A. HOLBOROW

Among the paintings of the Earlier Italian Schools in the National Gallery, London, is an attractive painting by Piero di Cosimo (Figs. 1 & 2). The picture is listed in the *Catalogue* under the title "No: 698. A Mythological Subject" and shows the body of a partly naked female lying on the banks of an estuary or river. Kneeling at her head is a satyr and seated at her feet a dog of the Labrador retriever type. In her neck is a wound which closely resembles a tracheostomy incision, and it is this which gives medical interest to the picture. This picture is described by Eastlake (1899) as "The Death of Procris," and if this title is accepted, the wound in explained. However, the *National Gallery Catalogue* (1951) states:

> The subject of No: 698 was doubtfully accepted by Eastlake as being 'The Death of Procris' (Eastlake's Notebook, 1858) and this has hitherto been admitted. It appears unlikely. According to the classical story, which is told with some variations, Cephalus killed Procris by mistake with a magic spear, and a dog sometimes called Laelaps was also associated with Cephalus and Procris. The correspondence with No: 698 is slight. To account for the satyr here, Schubring (P. Schubring, Cassoni 1923 pp 52/3) refers to the Fabula di Caephalo by Nicolo da Correggio, a play produced in Ferrara in 1486. Nicolo da Correggio does speak of a faun who stimulated the jealousy of Procris against Cephalus; but this seems to be a poor justification for the presence here of a faun or satyr, and for the absence here of Cephalus.
>
> Presumably No: 698 represents a different, hitherto unidentified subject; conceivably a subject from some Renaissance poem rather than from Classical legend.

Piero di Cosimo, a Florentine artist who lived between 1462-? 1521, was the son of Lorenzo di Piero and assisted Cosimo Rosselli, whose Christian name he assumed, in the decoration of the Sistine Chapel in Rome. He painted Old and New Testament subjects, also mythological subjects with many animals, introduced, and was one of the leaders in, the transition to the naturalistic style.

If it can be accepted that this is a painting of a tracheostomy, it is one of the earliest to be found. This view is given some support by the following:

a. Tracheostomy (known variously as Tracheotomy, Laryngotomy or Bronchotomy) is an operation of great antiquity. Dating back to Galen, it is said to have first been performed by Antonio Musa Brasavola (1490-1554). Fabricius ab Aquapendente (1537-1619), Professor of Surgery at Padua, gave a good description of the indications for surgery and the method to be used. Medical historians state that this operation, though often described, was never performed by earlier writers. The accuracy of description and illustration (such as are found in *De vocis auditusque organis historia anatomica*, by Julius Casserius, 1600) do not support this view, and it seems probable that they had more practical experience than is usually credited to them. In any case the operation was well known to surgeons at the time in question.

b. There is every reason to suppose that Piero di Cosimo, like other artists of his time, was as familiar with anatomy and medicine as his famous contemporary Leonardo da Vinci (1452-1519).

c. The wound is similar in appearance to those in the illustrations of Casserius. There is a short vertical incision with drops of blood running down on to the chest, as would occur with a tracheostomy performed in the sitting position customary at that time. Some blood has also fallen on to the left wrist and right hand.

d. The doubt as to the subject of the painting (referred to above).

e. Finally, there is the question of the reason for such an operation. I suggest that the background of the painting gives a clue. Is this not a case of drowning, possibly suicidal, with tracheostomy performed in an attempt at resuscitation? Two centuries later the employment of tracheostomy in the revival of the drowned was advised by Georg Detharding. In *Disputatio medica inauguralis de cynanche* (1723), it is mentioned that Detharding had written on laryngotomy in drowning: "de Laryngotomia in submersis adhibenda." Heister (1768) writes:

> If a drowned person has but just expired, or not continued long under Water, the most certain and expeditious Way of recovering him will be by opening the Trachea with a Scalpel, or such other Instrument as is nearest at hand, and afterwards to inflate or blow into his Lungs either with the naked mouth (as Delay is dangerous) or else with a Tube. For by this Means, if timely administered, the Breath and Life of a Person thus suffocated may be surprisingly restored, as DETHARDINGIUS, present professor of Physic at the Hague, has lately declared in a particular Dissertation upon this subject.

The two centuries between these statements and the painting by Piero may seem too long to make any conclusion possible. It must be remem-

FIG. 1. 'A Mythological Subject' by Piero di Cosimo.
(Reproduced by courtesy of the Trustees, the National Gallery, London.)

FIG. 2. Detail.

(Reproduced by courtesy of the Trustees, the National Gallery, London.)

bered, however, that during these two hundred years the operation of tracheostomy had advanced little if at all, and the number of successful cases reported in this time was only a handful. In addition, though earlier written mention cannot be found, it would seem unlikely that this was the first suggestion to be made that tracheostomy should be used in this common form of asphyxia, when it was advised for "suffocation" in general and for other forms less common.

The points enumerated combine to support the view put forward, and it would seem possible that this is a painting of a tracheostomy. It is not unlikely that Piero di Cosimo, having heard of the use to which this operation might be put, used it to add realism when depicting a case of drowning. If this is so, the painting is of considerable medico-historical interest.

ACKNOWLEDGMENTS

I am indebted to my friend Mr. Adrian Griffith for bringing this picture to my notice. The illustration is reproduced by courtesy of the Trustees, the National Gallery, London, to whom my thanks are also due.

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COMMENTS ON DR. ROMANELL'S ARTICLE ON LOCKE AND SYDENHAM

DAVID L. COWEN

Although time may well prove Dr. Romanell's article on Locke and Sydenham * an inspired piece of writing, I should like to express some words of caution and criticism.

It is certainly true that Dr. Romanell has been very careful to present the hypothetical nature of his argument. But I find that too often hypothesis becomes assumption, and assumption becomes conclusion. I illustrate by following the argument—the italics are mine, the words italicized are Dr. Romanell's.

The "Smallpox Fragment of 1670" Dr. Romanell describes as notes intended *apparently* for a preface to a work of Sydenham on smallpox. He goes on to cite evidence that Locke and Sydenham had projected such a work, and arrives at the *implication* that Locke was preparing a preface "in his friend's name." The "Fragment" contains, the account continues, probably the first statement of Locke's fallibilistic philosophy. This, on the basis of chronology and textual comparisons of Sydenham's works, was so influential on Sydenham, that, *at the risk of oversimplification*, Dr. Romanell submits the *suggestion* that it was *in all probability* Locke's influence that caused Sydenham to become more critical minded. A collation of texts follows in support of this argument, although *proof in the strict sense is out of the question here.* When Sydenham wavered from the new orthodoxy of fallibilism, it *seems* it was because personal contacts between Locke and Sydenham had become looser. At this point, it *should be clear* that Locke *must have* convinced Sydenham to abandon his original "molting" theory of smallpox. Thus, eventually, the argument suggests that it is Locke, not Sydenham, who should be called the English Hippocrates and that perhaps the chapter on seventeenth century medical history needs to be rewritten.

Dr. Romanell recognizes that the existence of two earlier Sydenham documents with "an underlying fallibilist note" (Sydenham's "Medical Observations" in the Library of the Royal College of Physicians, and

* Patrick Romanell, "Locke and Sydenham: A Fragment on Smallpox (1670)," *Bull. Hist. Med.*, 1958, *32*: 293-321.

Locke's transcription of Sydenham's "Treatise on Smallpox" at Bodleian, both 1669) might destroy his thesis entirely. He recognizes also that the "Fragment" may have been Locke's copying down of the words of Sydenham. This, too, would vitiate the whole argument. But Dr. Romanell *strongly suspects* that the thought came from Locke even if the actual words came from Sydenham. (It would help Dr. Romanell's case if the note on the verso of the "Fragment" read "Preface *for* Dr. Syd.," rather than "Preface *to* Dr. Syd.") This suspicion is founded on two arguments: first, that it "sounds so much like what was destined to be characteristically Lockean." This is an argument that might be labelled, "post hoc ergo hoc," and hardly eliminates the possibility that Locke learned his lesson initially from Sydenham. Secondly, the suspicion is based on three other earlier medical writings attributed to Locke: the "Anatomia" (1668), the "De Arte Medica" (1669), and a portion on "Morbus" in a medical commonplace book (1659-1666). This, I believe, is a questionable array of evidence and methodology.

The "Anatomia" is subject to exactly the same authorship problem as is the "Fragment." The first sentence of "Anatomia" is in Sydenham's handwriting, and Kenneth Dewhurst has recently suggested that the selection was "written in collaboration" and that, "It may even have been dictated by Sydenham to Locke." [*Medical History*, 1958, *2*:3.]

Moreover, while it may be said that the "Anatomia" is in the "same tone" of the fallibilist portion of the "Fragment" of 1670, the theme of the selection is empiricist. Anatomy is not "like to afford any great improvement to the practise of physic, or assist a man in findeing out and establishing a true method," for the anatomist cannot "perceive how [a gross part] performs its office," and "he cannot possibly see how nature prepares . . . and proportions." Instead, "diligent observation of . . . diseases, of their beginning, progress and ways of cure," is the proper path of the physician. The anatomist's deficiency is not said to be a limitation of human understanding, it is called a consequence of nature's tools "being too small and too subtle for the observation of our senses." This last is the thread that runs through the whole essay. No man can ever "come to a sight" of these minute parts, even with the "assistance of glasses or any other invention"; no one has "sight" adequate to satisfactory "occular demonstration"; our senses cannot "take cognizance"; "'twould puzzle the quickest sighted anatomist, assisted too by the best microscope."

The selection "De Arte Medica" (of which I have used Gibson's publication) is undoubtedly very critical of the search for hidden causes

and of hypotheses. It suggests, it is true, that " the workmanship of the almighty cannot be perfectly comprehended by any understanding." But it also suggests that this is true of " any one mans comprehension " and too great an undertaking " for his owne single endeavours," and that therefore the " mutuall assistance " of learned men is excited " to perfect the art & establish a setled certaine practise in the cure of sicknesses." Locke does not deny that " Method founded upon phylosophy & Hypothesis . . . contributed to the advanceing the Art of Physick," but these fell " short of perfecting it," for they involved " uselesse speculations," and " impracticall notions." The tenor of the selection is empiricist: the " usefull arts, & the assistances of human life, have all sprung from industry & observation[;] true knowledg grew first . . . by experience & rationall operations & had this method beene continued & all mens thoughts beene imploid to adde their owne tryalls to the observation of others[;] noe question physick . . . had beene in a far better condition than now it is."

Locke's selection on " Morbus " in the medical commonplace book he kept between 1659 and 1666 [Brit. Mus. Add. Ms. 32,554] and the only one of these three documents that pre-dates Locke's association with Sydenham, is the least weighty evidence of the three. (Dr. Romanell is correct, I believe, in noting that this document has not previously been mentioned by scholars, and that Locke sounds like a disciple of Van Helmont, but he does not recognize the significance of the latter for his argument.) The piece on " Morbus " is a very lengthy selection, perhaps the longest in the notebook. It begins before the index and bibliography but finishes up after them, leap-frogging other materials as well, and actually ending the notebook. This suggests that it was not fully planned all at once, and it may indeed have been unfinished. It is not followed either by the usual careful bibliographic citation, or by the initials " JL " by which Locke typically indicated his own responsibility for an item. Thus we do not know for sure whether this was Locke's own theorizing or whether he was copying or summarizing someone else's work.

Most important is that the tenor of this selection is rationalistic—it seeks to develop a theory of disease, and it is hypothetical and speculative. It begins with a statement that gives the gist of the whole:

> I suppose another & more rationall theory of diseases might be establishd upon other principles then those either of y^e^ Galenests or Paracelsians, for Considering y^t^ in y^e^ great world some things are produced by seminall principles, & some other by bare mistion of y^e^ parts, to w^ch^ might be added the circumstantiall assistances of heat & cold

Essentially the document argues that disease " seems wholy to depend upon y^e^ operation or activity of this seminall principle," and the " method therefor of cureing those diseases I suppose would be to finde out remedys to destroy those particular ferments, & to fortifye y^e^ parts agt their operation." Locke (or his source) further supposes that " Other deseases . . . may probably be conceived to be producd by a bare mistion of two unfitt ingredients."

Dr. Romanell has Locke confessing *characteristically* that he " cannot satisfactorily comprehend how the ' insensible ferments ' produce diseases." The whole statement is as follows:

> How these small & insensible ferments this potent Archeus works I confesse I cannot satisfactorily comprehend, though y^e^ effects are evident[,] but [?] y^t^ I beleive 'twould be worth considering to finde what deseases spring from these ferments

Be it noted that Locke (assuming his authorship) admits only that he does not understand how the process works; that he does not deny the existence of ferments nor dispute the concept of an Archeus. In short he is arguing an hypothesis throughout, and in this context particularly, this one diversion may more readily (note the " evident effects ") be labelled empiricism than fallibilism.

Dr. Romanell has selected from each of these those portions and ideas that fit his hypothesis, regardless of the total tenor of the document. This might be a sounder method if he were tracing the evolution of an author's idea, where both the authorship and the idea were already indisputable. To some extent he has done the same thing with the " Fragment " and with Locke's transcription of Sydenham's " Treatise on Smallpox " (1669). The total statement of the " Fragment " (line 12) includes the concept that hypotheses by themselves are not " sound & sure enough without experience to warrant our practise or lead us into the right way of operacon." This is empiricism. The parallel quotation from the 1669 transcript he speaks of as also being " agnostic." This is true only of the first of the two sentences quoted. The second contends that the writer is inclined to believe that smallpox is an inflammation in the blood and humors on the basis of " the more strict consideration of the severall phaenomena." Again, an empiricist statement.

I must thus take exception to the claim, based largely on the " Morbus " selection, that Locke was " a medical fallibilist from the very beginning of his career." There is a good deal in the notebook which contains this selection, as will be pointed out, that makes this a doubtful statement.

Moreover, if Locke's career can be said to have started earlier, one can point to an earlier medical commonplace book (1652-54/5) which contained directions for compounding sympathetic ointment (beare-greace, the fatt of a boare—the staler the better, mosse from the scull of an unburied man, earthworms, *et al* and for applying it to " the weapon wherewith the patient was wounded," [Bod., Locke Ms. e. 4, p. 11] and which recommended for the measles, " If you suspect that blindnesse shall ensue . . . then hang scabios [an herb] about their necks." [*Ibid.*, p. 7] These two items may prove little, but they hardly indicate the skeptical attitude underlying fallibilism.

Similarly, I must raise a question as to the validity of the statement that Locke was a " budding critic of authoritarianism and dogmatism in medicine " when he met Sydenham. The notebook which contains the selection on " Morbus " needs closer examination in this connection. The last date in it, the date of a book cited by Locke, is 1666 (not 1664 as Dr. Romanell states—the two years are very important here, for they mean that this notebook was kept virtually up to the time Locke's connection with Sydenham began), and I find in it the following evidence that Locke might still have been authoritarian and traditional in his medical thinking:

First, it contains the rationalistic, systematized selection on " Morbus " discussed above.

Second, it is replete with biographical references in the superlative. For example, Locke copies Glisson's description of Hildanus as " Diligentiss . . . Chirurgus celeberrim.' " This suggests a respect for authority hardly becoming a critical empiricist (or fallibilist).

Third, and most important, the notebook is composed of a vast number of quotations from many sources, carefully classified, documented and indexed. Locke was selective, but it is significant that out of the 31 dated books in his bibliography of 37 (not all the books cited in the notes show up in the bibliography), 14 were published between 1538 and 1609; that is, from 121 to 50 years before the notebook was begun. This, too, is not the technique of an empiricist or fallibilist. The overall effect is, on the contrary, encyclopedic, traditional, and authoritative, as the following excerpts demonstrate. (I have selected the portion on " Variolae " to point up the absence from Dr. Romanell's discussion of any consideration of what Locke thought or knew on this subject before he met Sydenham.)

Smallpox

The poison of these remains chiefly in the more subtle parts of the blood. v.p. Velthus, c. 60, p. 140.

Who shun the use of *lens* [probably duckweed, possibly lentils] in smallpox and measles have not been experienced in the practice of the art, writes H. Augenius, On Fevers, l. 10, c. 9. He teaches that it helps by virtue of its properties. But A. Portus, On Smallpox, l. 4, c. 21, believes that it is helpful by virtue of its astringency. Sennert, Inst., p. 524.

That ferment which excites so much boiling in the blood and produces smallpox, seems to take root in the nerve juice and from there to be communicated to the blood mass. 1st Because at the onset of the smallpox, the pain is perceived first in the head and thence in the tubes [?] and nerve part[?], without a considerable change in the blood. 2nd Because, in the beginning of the disease, before the miasma [?] has entered that blood mass and excited the fever, cathartics, when applied, are extremely useful by withdrawing matter from the forming efflorescence, and render the disease more mild; when, however, the blood already boils up, and begins to deposit the dross in the more external parts, a purge [becomes] dangerous. c̄ Willis.

When the tension of the belly sounds like a drum, it is considered to be a fatal sign by River., Obs. Cons., 62, 1656 and Forest., c. 1, c. 65, 17, n. 8. Q[uery] Or is this perhaps not the latter's [opinion]?

As a symptom, worms should be present; they are usually developed in malign fevers, in which there are also signs of worms. By Sennert, p. 3, p. 2, s. 1, c. 5, p. 419, 1656; and perhaps the desperately sick of this kind may be preserved by remedies appropriate for killing worms. JL [for John Locke] [Translation, *loc. cit.*, pp. 144-145]

Fourth, the traditional and bizarre in the materia medica find a place in the notebook. For example, such items as Mithridati, unicorn, and bezoar stone are indexed in it. The last receives more than passing treatment: the water in which the bezoar stone is steeped is said by the people of Pan, near Malacca, to be a " most soveraigne antidote agt all poyson, & an effectuall cordiall agt all infectious deseases." A report from Italy speaks of the herb basilico which " produceth a scorpion " if kept under a stone in a moist place for two days, and which, when powdered and used as a snuff caused a man to die " distracted," in whose skull post-mortem examination disclosed " a nest of Scorpions . . . feeding on his braines." Again, two or three drops in the ear of the fat that drips from a roasting silver eel that had been skinned and gutted, but not washed, is reported to cure deafness, and the powdered ashes of tortoise shell, mixed with egg whites, are said to prevent " y^e^ falling of the haire." [*Ibid.*, pp. 154, 33, 142, 10, 218, 9]

It is dangerous to assume that Locke's copying of such items in his notebook constituted either acceptance or endorsement, although one looks in vain for any sign that these items were put down with a critical or perhaps humorous intent. This evidence alone is hardly sufficient to cate-

gorize Locke as a complete traditionalist at this time; but it does at least call for a pause in accepting the conclusion that Locke was a critic of authority and dogmatism when he met Sydenham.

Thus I find it difficult to accept the thesis of Locke's philosophical influence on Sydenham as proven on the basis of the evidence presented. Dr. Romanell's assertion that Sydenham owed his critical approach to Locke, while the latter owed his appreciation of "the empirical method in the concrete" and his way out of his own medical agnosticism to Sydenham, I find contradictory and confusing. On the one hand we are told that Sydenham "is intellectually indebted to Locke . . . for the adoption of a more critical approach to medicine," and on the other that "it is actually the Sydenhamian physician . . . in Locke that make[s] him think that way." Again, we are told both that whatever skepticism in medical theory Sydenham came to have, "must have been due to some extent" to John Locke, and that "Locke's logic is Sydenham's logic of medicine generalized."

I must also take exception to three specific arguments adduced by Dr. Romanell. Why else, he asks, could Sydenham have been quite confident about understanding smallpox before he knew Locke, but not so confident after he met him, if it were not the influence of Locke? May I suggest that Sydenham's clinical experience, which was undoubtedly large, may have raised doubts in his mind.

The second is Dr. Romanell's finding in the "Fragment" a clear "statement of Locke's pragmatic test of language," when he reads it (line 18) to say, "noe great difference between oake & berch wch though differing words in them selves did by some common quality produce flame and heat." This is not an argument readily followed, but it loses any significance if the manuscript is alternatively, and perhaps more reasonably, read to say "differing *woods*." (I would point out that this sentence, speaking of a common quality, is hardly fallibilistic.)

The third is Dr. Romanell's *guess* (valuable in building up his case for the medical foundations of Locke's philosophy) that the subject of conversation which led to Locke's writing of the *Essay Concerning Human Understanding* was medical. This guess is based on certain *circumstantial evidence*. One piece of such evidence is the fact that two of the five or six friends present were physicians. Isn't it more plausible to guess that since three or four, a majority of the group, were laymen, that the topic was not medical? Another bit of circumstantial evidence offered is the extremely poor health conditions that existed in England at that time—so bad as to make them a fit subject for conversation. Circumstantial or

remote? And finally, the "Fragment" of 1670 is presented as an index "to Locke's particular state of mind" in that year, the same year in which he first drafted the *Essay*. The circumstantial evidence is now circumferential as well; the original hypothesis has become circumstantial proof for a guess.

I leave to philosophers the discussion of whether or not, as Dr. Romanell contends, fallibilism is the *leit motif* of Locke's "entire work after 1670"; whether or not Locke's logic in the *Essay* was a contribution to natural history, and not to natural philosophy; whether or not "the new way of ideas" and distinctions "between 'real' and 'nominal' essences" are "verbal baggage" in the *Essay*; and whether or not "it is much easier to make intelligible the agnostic outcome" if one starts with medicine rather than with physics. But I believe that Dr. Romanell's presentation is subject to the general criticism that a single statement, in a "Fragment" attributed to Locke, grows until it represents a generalization from Locke's medical experience, and in turn this medical experience becomes the basis of his whole philosophy.

It may well be that Locke's medical experience played a much more significant role in forming Locke's philosophy than is usually attributed to it, and that here Dr. Romanell has contributed a distinct service. Yet his cavalier treatment of the influence of the physical sciences and of the philosophy of others on Locke's philosophy, is difficult to accept when one is familiar with the wide range of Locke's reading and study in these fields, and is aware of the studies of the influence, for example, of Descartes on Locke.

Finally, if Locke's medical experience was of significance in the formation of his philosophy, the process whereby Locke turned from the traditional and systematic medicine found in his earlier notebooks, to empiricism, still needs to be explained. This process probably took place in the 1660's, perhaps simply as a consequence of actual medical practice, perhaps as a consequence of his association with Sydenham (started in 1667), perhaps as a consequence of reading and study, or his dabbling in chemistry. The process can only be revealed by the thorough examination and study of the myriad of medical and other papers in the Shaftsbury Papers in the Public Record Office, the Locke Mss. in the British Museum, and the Lovelace Papers in the Bodleian Library, and others.

MEDICO-HISTORICAL NEWS AND ACTIVITIES

ANNOUNCEMENTS

AMERICAN ASSOCIATION FOR THE HISTORY OF MEDICINE

Thirty-Second Annual Meeting: Cleveland, Ohio, May 21-23, 1959, at the Cleveland Medical Library, 11000 Euclid Ave. Headquarters hotel: The Wade Park Manor, East 107th & Chester Ave.

NATIONAL NEWS

American Academy of the History of Dentistry

At the annual meeting of the Academy, November 7, 1958, Robert Thoburn was installed as president; Van B. Dalton was chosen president-elect; Harry B. McCarthy was elected vice-president; and the following officers were re-elected: Milton B. Asbell, secretary; George B. Denton, editor.

Curt Proskauer of New York City and Luigi Casotti of Milan, Italy, were elected honorary members.

New York University

A series of public lectures on "Medicine and Society in Early America" was delivered by Richard Harrison Shryock under the Anson G. Phelps Lectureship on Early American History. Dr. Shryock spoke on: "Medical Theory and Practice," February 25, 1959; "Disease and the Public Health," March 4; "The Medical Profession," March 11; "The Fate of Eighteenth-Century Viewpoints in the Victorian Era," March 18.

Philadelphia

The Free Library of Philadelphia is proud to present an exhibit of the magnificent work of Dr. A. Süheyl Unver, Professor of Art in Turkish Miniature at the Academy of Fine Arts in Istanbul, and Director of the Institute of the History of Turkish Medicine. The exhibit includes miniatures, calligraphy, illumination, and book bindings by Dr. Unver, together with rare Turkish manuscripts from the Library's John Frederick Lewis Collection of Oriental Manuscripts. The exhibit is on display from nine to five-thirty, Monday through Saturday, at the Rare Book Department in the Library's Logan Square building, until the thirteenth of April.

University of Kansas School of Medicine

The ninth Logan Clendening Lecture was delivered by Dr. Edward H. Hashinger on March 12, 1959. The title of his lecture was: "Arthur E. Hertzler—the Kansas Horse and Buggy Doctor."

PROGRAMS OF MEETINGS

Beaumont Medical Club (Yale)

January 15, 1959: "William Rimmer, Artist and Physician," Richard Nutt; "The Search for the real Nathan Smith," Oliver S. Hayward.

Benjamin Waterhouse Medical History Society

March 16, 1959, combined meeting with the Providence Medical Historical Society: "The Hospital at Portsmouth Grove," Seebert Goldowsky.

April 13, 1959: "Medicine in the Arctic," Lamar Soutter.

Johns Hopkins Medical History Club

March 31, 1959: "Science and Medicine in the Work of Rhazes," Salomon Pines.

May 1, 1959: "The Prediction of Sex: Superstition and Science," Thomas R. Forbes.

Society of Medical History of Chicago

March 11, 1959: "Syphilis and the Revolution in Morals," John Chynoweth Burnham; "Hypnosis and Suggestion: Historical Reflections," Ilza Veith.

NEWS FROM ABROAD

Frans Jonckheere (1903-1956)

Dr. Jonckheere belonged to the very small group of medical historians qualified to do original work on ancient Egyptian medicine. Born in Brussels, June 30, 1903, he received his M. D. degree from the *Université Libre* of that city in 1928 and proceeded to specialize in surgery. About eleven years later, he became the pupil of Professor B. van der Walle, thus starting on his egyptological career. He was active in medicine as well as in the general field of medical history, and in that of his specialty, to the end of his life, some of his most important publications appearing posthumously. Obituaries, followed by lists of the publications of Dr. Jonckheere, have been published by Professor van der Walle (*Histoire de la Médecine*, July 1956, *6*: 73-76) and by Ernest Wickersheimer (*Archives Internationales d'Histoire des Sciences*, 1956, *neuvième année*, no. 35: 176-177).

Germany

A full professorship of the History of Medicine has been instituted at the University of Munich.

India

The Department of History of Medicine, opened in September 1956 in the Andhra Medical College, Visakhapatnam, and transferred to the Osmania Medical College, Hyderabad, in March 1957, is now accommodated in the Nizam Bagh Guest

House, Inside Salar Jung Museum Compound, Hyderabad. It has now been upgraded with the aid of the Government of India.

Dr. D. V. Subba Reddy, MBBS., M. Sc., Professor of History of Medicine, has been appointed Director of the Upgraded Department or Institute of History of Medicine, and additional staff, such as a Librarian and Sanskrit and Arabic Scholars, are being appointed. In addition to the course of ten to twelve lectures for undergraduates, and the two to four lectures on each of the specialties for post-graduates studying for diplomas and degrees, the Osmania University has recently instituted a Post-graduate Diploma in History of Medicine, study for which extends over one year.

The Department or Institute of History of Medicine will be glad to exchange programmes of lectures, syllabi, reports of departments of the history of medicine, reprints and publications, duplicates, and other materials, with institutions or individuals interested in the subject.

All interested persons and institutions are requested to note the new address: Upgraded Dept. of History of Medicine, Osmania Medical College, Nizam Bagh, Diwan Devdi, Hyberabad-Dn., Andhra Pradesh, India.

LOUIS COHN-HAFT. *The Public Physicians of Ancient Greece.* (Smith College Studies in History, vol. XLII). Northampton, Massachusetts: Smith College, 1956. x + 91 pp.

The present volume is a new, soundly-argued and well-documented approach to an old problem. The problem about which the study turns is the nature and function of the public physician in ancient Greece. Considering the bulk of ancient literature, it is surprising that there is so little evidence concerning the public physician. Nothing undaunted, scholars have produced an impressive number of studies. All of them, our author informs us (p. 3) are vitiated by a methodological defect. Its reparation is the *point d'appui* for the present study.

The method of explanation adopted by Cohn-Haft is simple: all the relevant literary and epigraphical evidence must be interpreted consistently and reasonably but without adopting as premises supposed similiarities or analogies with Roman or later Greek medical practice. The scant literary evidence on which many of the older interpretations rested (e. g. schol. Aristoph. Acharn. 1030; Diod. XII, 13, 4; Hdt. III 131) is minimized by Cohn-Haft on the grounds that the much larger collection of epigraphical evidence does not support it. The best case would seem to be the scholium mentioned above; it states that " the physicians appointed by the state being public officers were accustomed to attend upon the sick without fee " (Rutherford's transl. ap. Cohn-Haft p. 33). Cohn-Haft argues that there is no evidence dating from Aristophanes' time, literary or epigraphical, which justifies the claim of the scholiast. But still, the scholium and the other literary evidence must be explained. In order to accomplish this, Cohn-Haft, relying on epigraphical data, adopts a method free from those assumptions tailored to fit the literary evidence. Rather than prejudge the issue concerning the nature of the public physician's task, he is defined as " one who had some kind of official connection with the state " (p. 5). The problem, then, is to determine what the relation was. At this point our author turns to the inscriptions and by examining them on the basis of two criteria, " institutional characteristics " and " titulature " (*loc cit.*), 66 inscriptions are selected as relevant. (NB: bibliographical information, date, provenance, etc. of the inscriptions, denoted as Doc. No. 1 . . . 66, will be found in the Appendix, pp. 76-85.) Each inscription adds a jot to the story: the name of a public physician e. g., Pheidias (Doc. No. 5); Hermias (Doc. Nos. 18, 19, 29); Damiadas (Doc. No. 51), sometimes also attested to in literary sources (e. g., Evenor, compare Doc. Nos. 3-4 with Athen. II, 46 D; Philotas of Amphissa, compare Doc. No. 58 with Plut. vit. Anton. 28); the fee or stipend (Doc. No. 48); the remission of fee or stipend (cf. p. 35 note 11); contracted length of service (e. g., Doc. Nos. 24, 37, 51 etc. cf. p. 47 and notes); the physician's homeland e. g., Xenotimus of Cos (Doc. No. 13), Philistus of Cos (Doc. No. 20), Menocritus of Samos Doc. No. 37).

A careful analysis of the relevant texts, with reference to both content and style, permits, our author concludes, only two possible explanations of the public

physician's function and his relation to the state: (1) "Guarantee of a physician's residence in a given community" and (2) "Official public endorsement of a given physician's qualification to practice in a particular community" (p. 44). Chapters 4 and 5 are devoted to proving that the two explanations are complementary and together consistently account for the bulk of the evidence. The merit of this explanation is that it resolves some of the cruces which plagued earlier interpretations. Thus, in Chapter 4, an analysis of the citizenship of known public physicians reveals a 2:1 ratio in favor of foreign physicians practicing in a given city. This explanation accords well with the epigraphical evidence concerning itinerant physicians (cf. p. 21), contracts, and requests to "send out" a physician (cf. *infra*). In turn, this is explained by the fact that all but the largest cites lacked facilities for the training of physicians and consequently offered a bonus or an annual stipend to the physician who would reside and practice within that city for the contracted length of time. The Aristophanic scholium thus must be interpreted in the light, not of free medical care, but in the sense that the physician who received a stipend may, circumstances permitting, remit a fee to which he is legally entitled (Doc. Nos. 5, 51). Such an explanation is based largely on a novel analysis of such subtle distinctions as δωρεάν ∽ προῖκα; the former, it is suggested (pp. 35 n. 11, 60 n. 23) means "remission of stipend," the latter, "remission of fee" (= ἄνευ μισθοῦ) and the tri-fold distinction of δημοσιεύειν ∽ ἰατρεύειν ∽ ἰδιωτεύειν. The former of these three terms means "to be a public physician" (pp. 5-6) and is thus contrasted with ἰατρεύειν, "to practice medicine" (p. 7) and ἰδιωτεύειν, "to be not yet ready or qualified to practice (publicly)" (p. 59 n. 19).

In Chapter 5, our author relies rather more on literary evidence to establish his contention that because the cities requesting foreign-trained physicians lacked any form of responsible licensure they protected themselves, and their citizens, by requiring candidates for the post of public physician to appear before an examining board (e. g., Pl. Gorg. 455 B, 456 B). The physician who pleaded his competency in such a manner is to be contrasted, states Cohn-Haft, "not with a physician in private practice, but with a non-professional" (p. 59). As before, such an explanation has much to recommend it. It accounts for the facts that Cos regularly received requests from foreign cities to send out Coan-trained physicians (Doc. Nos. 18-19); that inscriptions frequently speak of a physician as elected (Doc. Nos. 19, 46), hired (Doc. Nos. 33, 48b), or sent for (Doc. Nos. 43, 47-51); that honorary decrees, copies of which were sent to the physician's home city, were the means of advertising the physician-candidates' abilities (cf. p. 66).

The author admits on several occasions (e. g., pp. 60 n. 24, 67) that his thesis is novel and rather more speculative than might be wished. The present reviewer, however, has only a few serious reservations. One concerns the surprising omission of any reference to the *Iatrikon*, a state fund, supported by taxes, to support the doctors, cf. SIG[3] 437 and Woodhead, *Cambr. Hist. Journal* 10 (1952) 242. Cohn-Haft overlooked IG II Add. 256b (= SIG[3] 335) with its almost certain reading δημοσιεύειν δωρε[ά]ν but this, like other evidence omitted (e. g. Strabo IV, 181 and Hesych. sv. δημοσιεύειν) rather confirms than weakens his argument. These few remarks in no way diminish the value of a work sure to be required for all future historians of public medicine. The time may come when further epigraphical finds or papyri will settle the story; in the meanwhile an investigation of the representations on Greek vases may shed some further light on the matter. Careful proof-

reading is in evidence throughout; two printer's errors (p. 5 n. 4) mar an otherwise perfect job of Greek type-setting. The reference to Oldfather on p. 85 should be W. A. Oldfather, not his brother C. H. It is greatly to be regretted that Cohn-Haft did not supply us with the texts of the inscriptions on which he so heavily relies. To search out the texts from some dozen epigraphical publications requires much time and a good library. The remarks appended to the documentation of the inscriptions are unfortunately totally inadequate. There is no way of knowing, short of making one's own index, e. g., that the physician referred to in Doc. No. 51 is Damiadas or that Heracleitus is the physician referred to in Doc. No. 63 (incidentally, IG Rom. III 733 should be mentioned). No mention is made of the fact that T. Claudius Tyrannus of SIG³ 807 (= Cohn-Haft Doc. No. 62) is granted freedom from taxation in view of his establishing ἐργαστερία which Woodhead *op. cit.*, p. 244 likens to dispensaries, a usage unattested in LSJ and not mentioned by the present author.

JERRY STANNARD

ALFRED HURWITZ and GEORGE A. DEGENSHEIN (Editors). *Milestones in Modern Surgery*. New York: Hoeber-Harper, 1958. xviii + 520 pp. Ill. $15.00.

This is an extremely valuable book and one that every surgeon will wish to have. The plan is excellent and the execution admirable. There are 13 chapters, the first 11 dealing with various fields of surgery—the 12th poetically entitled "The Soul of the Surgeon," and the 13th, "Milestones on the Horizon." In plan the chapters are similar, there is a brief prefatory comment, and there follow reproductions of chosen articles in the field, with photographs of the authors and brief biographical notes.

The most serious criticism which may be made of the book is that the introductory comments on the subjects of each chapter are much too cursory and superficial. The list of potential candidates for inclusion in a work of this kind is so great, and their various claims to inclusion are so frequently a matter of individual opinion, that it is unlikely any selection would ever satisfy all readers; no more can the present reviewer understand a work of this kind without inclusion of the classical papers of Lister, of Fitz, and of Blalock, to cite only three. The book would have been made enormously more valuable had the brief "prefatory comments" been expanded to the status of authoritative historical reviews, including for the student the references to other basic works.

This is, after all, a work of history, and as such it might benefit from greater detail in the biographical sketches of those whose works are presented. The sketch, by Isadore Cohen, of Matas is delightful and Matas comes alive, but most of the others are so brief as to be unilluminating and in many instances fail to tie the subjects to the events and times which form their background. The biographies of some of the still living subjects are occasionally more fulsome in their praise than is seemly, while the few lines devoted to Owen Wagensteen give no hint of his scientific stature or of the fertility of the surgical clinic he heads.

All the cited authors of the last century or before are familiar to the most

casual surgical reader, and none of their works can be considered obscure. It is not certain that as much will be said in 50 or 100 years of some of the contemporary surgeons included.

Finally, and it is realized that the desire to limit the size of the book may have had much to do with the brevity of the biographies and of the prefatory comments, one would hope that in a future edition the omission of neuro-surgery from the volume would be corrected.

MARK M. RAVITCH

JUAN B. LASTRES. *Medicos y Cirujanos de Pizarro y Almagro.* Lima: Editorial San Marcos, 1958; 94 pp., Ill.

It has been said that the Conquistadores had neither medical nor surgical assistance on their expeditions in America. This is not true of Peru. Dr. Hernando Sepúlveda had come from Spain to Santo Domingo, thence to Panama, whence he traveled to South America with Pedro de Alvarado in 1534. Alvarado, hoping to share in the Pizarros' plunder, was dissuaded and returned to his own Guatemala. Sepúlveda attached himself to Francisco Pizarro who went on to found Lima in 1535. The physician established himself in the City of the Kings with a good house and four slaves. He was useful on diplomatic missions and was appointed first Protomedico of Peru, April 20, 1537. His chief responsibility was to regulate medical practice, discourage charlatans, fix fees, inspect drugs in pharmacies, rejecting adulterated medicaments, to prohibit abortion and to establish a smoothly working organization. During this period the Pizarros were involved in Indian uprisings, and Sepúlveda sent his business partner, the apothecary Rodriguez, with drug supplies to the army and shared in the profits from this venture. On July 28, 1539, Sepúlveda petitioned the Cabildo of Lima for permission to return to Santo Domingo where he had left his family, intending to bring them to Lima. Instead, he returned to Spain, where he died in 1542. And until that time the Protomedicato remained vacant. His successor continued his work of enforcing adherence to rigid Hippocratic ethics.

When Francisco Pizarro suggested that Almagro, who felt himself slighted in the disposition of royal favors, titles, and land grants, go to claim the kingdom of Chile, the Bachelor-Surgeon, Marín, with medical supplies, was one of this company. The journey over snow-covered mountains is vividly described as an unending struggle with hostile natives and hostile winter weather. Finding Chile barren and inhospitable, they returned to Peru. The surgeon, Marín, was invaluable in giving aid to the freezing soldiers. Almagro returned to Cuzco during the Indian uprising of Manco Inca, 1537, and plunged into conflict with the Pizarros, which ended in his defeat at Las Salinas, 1538. The Bachelor-Surgeon Enríquez, who had met him on his return from Chile, attended him here and seems to have replaced Marín. He stayed with Almagro till the general was executed, July 8, 1538. Since Almagro's property was confiscated by the Pizarros, Enríquez never received the legacy willed him by his chief. Later he attached himself to Francisco Chavez, and, becoming involved in politics, was garroted along with his guide in 1541.

His origin and education are unknown, and his professional services lasted little more than two of the seven years in Peru. His courage, honesty, and humor endeared him to his patients, as well as his ethical discharge of his surgeon's duties. We know little of Marín, especially after he was replaced by Enríquez. He wandered from city to city and finally settled in Lima to practice his art.

Of the three, Sepúlveda ranks highest as the physician trained at Salamanca. Enríquez had studied medicine but acquired no title, yet was thereby superior to the surgeon Marín.

GEORGIANNA S. GITTINGER

GUSTAV SCHERZ. *Nicolaus Steno and His Indice.* Copenhagen: Munksgaard, 1958 (*Acta historica scientiarum naturalium et medicinalium*, vol. 15). 314 pp. Ill. Dan. Kr. 32.–

Two years ago Gustav Scherz published *Vom Wege Niels Stensens*, a biography of one of the most outstanding figures in the history of 17th century science, Niels Stensen, or, latinized, Nicolaus Steno, the Danish anatomist and scientist. The book was reviewed in the *Bulletin of the History of Medicine* (1958, *32*: 86) and in the review it was mentioned that Dr. Scherz was preparing yet another volume on the same subject, written in English.

This work, which is essentially different from the preceding, has now seen the light. The new book on Stensen is not altogether in English, but is an international composite work, to which six other authors besides Dr. Scherz have offered contributions illustrating Stensen's many-sided research.

Writing in English, Dr. Scherz has again gone through the sources and gives on this basis a painstaking account of Stensen's life and scientific work. He fixes the exact dates of the great events in Stensen's life, describes his journeys and mentions the scientists he met on his way. Of special importance is the demonstration of the fact that Stensen, who never visited Britain, made the acquaintance of outstanding British scientists during a stay at Montpelier, and through them he came into contact with The Royal Society.

Ragnar Spärck, Professor of Zoology in the University of Copenhagen, also using English as a medium, deals with Stensen's contribution to zoology, calling attention to his discovery that the reproductive organs of female mammals—in those days called *testes muliebres*—were not to be regarded as organs corresponding to the testes of male mammals, but that they were in fact the same organs as the ovaries of the oviparous animals. This theory was advanced by Stensen as early as 1667, or five years before de Graaf's famous work appeared.

Rémacle Rome, Conservateur du Musée de Paléontologie de l'Université de Louvain, writes in French on Stensen's work in the field of palaeontology and describes how Stensen, dissecting the head of a giant shark, *Charcarodon Rondeleti*, noticed that the shark's teeth were like the so-called *glossopetrae*, tongue-like stones found in the earth, e. g. in Malta. Contemporary scientists had nothing to say about these "tongue-stones" beyond the theory that they must have been formed in the earth by some *vis plastica*. To Stensen goes the credit of demonstrating

that *glossopetrae* were actually fossil sharks' teeth; he explained that if fossilized remains of marine animals were found far from the shores, it is because the earth's strata, down through the ages, were deposited by the sea.

This was the introduction to comprehensive studies which made Stensen the founder of scientific geology, and that aspect of his research has received full treatment in English by Axel Garbo, Ph. D., Copenhagen.

Hermann Tertsch, Professor of Mineralogy in the University of Vienna, describes in German Stensen's services to crystallography. Stensen showed that for the same form of crystal the angles between similar pairs of faces are always the same, irrespective of the origin of the crystal. This is the so-called first crystallographic principle, now often called Steno's law.

Adolf Faller, Professor of Anatomy in the University of Fribourg, Switzerland, writing in German on Stensen's relations to Cartesianism, shows how Stensen's detached studies carried him to a slashing criticism of various aspects of Descartes' speculative biology.

Finally, the geologist V. A. Eyles, D. Sc., of Bristol, gives a survey of the influence of Nicolaus Steno on the development of geological science in Britain. Appearing in 1669 in Latin, Stensen's work on geology was translated into English only two years later by Henry Oldenburgh under the lengthy title of "The prodromus to a dissertation concerning solids naturally contained within solids. Laying a foundation for the rendering of a rational accompt both of the frame and the several changes of the masse of the earth, as also of the various productions in the same."

To the book under review, as to *Vom Wege Niels Stensens*, is appended a transcript of the so-called Indice MS, an inventory of Stensen's collection of fossils, minerals, crystals etc., written in Italian and here provided with an English translation.

It was a very good idea to draw in specialists to elucidate the various facets of Stensen's research, and this new book reflects great credit on Dr. Scherz. Only Stensen's anatomical work which, after all, won him early fame, is somewhat thrust into the shade, though touched on in different sections. Thus, we still lack a comprehensive, scholarly account of Stensen's fundamental work on glands, muscles, and the heart.

EDV. GOTFREDSEN

EDGAR FRENK. *Johann Rudolph Burkhards Syllogae Phainomenon Anatomikon, ein Einblick in das Krankengut des Zürcher Spitals vor 200 Jahren.* (Veröffentlichungen der Schweizerischen Gesellschaft für Geschichte der Medizin und der Naturwissenschaften, XXII) Aarau: Verlag H. R. Sauerländer & Co., 1958, 53 pp. 5.20 Swiss francs.

This informative and stimulating monograph in the series of publications of the Swiss Society for History of Medicine and Natural Sciences is a chapter of the evolution of pathologic anatomy during the 18th Century. It refers to and reflects upon the activity of Burkhard who was prosector at the anatomical theatre from

1745 to 1780, and it is based upon a collection of 500 handwritten, partly illustrated autopsy protocols, dated 1752 to 1774, found in the Central Library in Zürich.

The brochure gives new insight into the state and significance of morbid anatomy in Switzerland, a country which has contributed so much to the recognition of pathologic anatomic observation as an instrument for the advancement of medicine. The life and work of Burkhard illustrate the emancipation of morbid anatomy as a science of medicine independent of systematic physiological anatomy, an 18th Century development, that consolidated the principle of clinical-anatomic correlation which culminated in Morgagni. This idea was not alien to the thinking and endeavor of the great anatomists of the two preceding centuries who were keenly interested in abnormal findings at autopsy, not as mere curiosities, but because of their significance for a rational comprehension of symptoms of disease and its cause. The appreciation of morbid anatomy is clearly expressed by Eustachio in Chapter 45 of his treatise on the kidney, it pervades Bartholin's *De anatome practica ex cadaveribus morbosis adornanda consilium*, and led William Harvey in his letter to John Riolan to the statement, "and I daresay that the opening and dissection of one consumptive person or of a body spent with some antient or venemous disease has more enriched the knowledge of Physick than the dissections of ten bodies of men that have been hanged." One may well ask why more than two hundred years had to pass between the appearance of Vesalius' epoch-making *Fabrica* and that of Morgagni's *De sedibus* which raised the curtain for the era of morbid anatomy. Rational pathologic anatomy could come into existence only after the foundations of physiologic anatomy had been fully secured, but its universal elaboration further depended on ever expanding empirical knowledge. Thus Morgagni's systematization could come to realization only in Italy, where dissection had been practiced without restriction for generations. In northern Europe, however, post mortem examination met with great resistance, and to this Schenck von Grafenberg ascribes the retardation of medicine in Germany. Burkhard's life illustrates the precarious circumstances which interrupted the auspicious growth of pathologic anatomy in Switzerland. Johann Jacob Wepfer had been authorized in 1650 to perform necropsies on all patients who died in municipal hospitals in Schaffhausen, and Von Muralt was given the same privilege in Zürich. But when he retired in 1724, his life work collapsed. Burkhard, his successor twenty years later, reports how he was prevented by personal threats from the exercise of his duties. Only in 1752 was the situation improved through the intervention of councillor Heinrich Rahn, a great friend of science. The attitude of this enlightened layman is paralleled by that of Diderot who, in his *Encyclopédie*, under "cadavre," makes a strong plea for obligatory autopsies. The liberalization of post mortem examinations which soon spread throughout Europe was a decisive contribution of the era of enlightenment to the cause of pathologic anatomy and of medicine.

In 1754, Burkhard became the first salaried prosector of a hospital not affiliated with a university. He recorded his anatomical findings in autopsy protocols which included abstracts of the clinical history, indicating his endeavor to correlate observations in the living with those in the dead. The morbid alterations are so clearly described that Frenk states that they can mostly be identified according

to present-day pathologic anatomic criteria. He includes a few original protocols and three exquisite drawings by Burkhard's hand of an osteogenic sarcoma of the humerus, a liver cirrhosis, and an ovarian neoplasm. Frenk gives a detailed survey of the accumulated data according to modern principles of classification and makes imaginative comments in reference to the differences in the necropsy material of Burkhard's period and of today and the possible reasons for the discrepancies.

PAUL KLEMPERER

IAN A. PORTER. *Alexander Gordon, M. D., of Aberdeen, 1752-1799.* (Aberdeen University Studies Number 139) Edinburgh and London: Published for the University of Aberdeen by Oliver and Boyd, 1958, xii + 92 pp. Ill. 12s 6d net.

At the present time, scientific medicine is intimately connected with precision apparatus and experiment. But these, while important, are not really essential. More important are critical observation and judgment. The present monograph demonstrates this fact quite unequivocally. The almost forgotten Scottish physician, Alexander Gordon, one of the few obstetricians of the late 18th century, distinctly perceived the contagious nature of puerperal fever, and, by brilliant inference, traced its causes up to the limits of available knowledge. Obviously he did not entirely solve the problem. Streptococci, of course, were then unknown. That he did not know the unknown, is no ground for criticism. But his scientific insight clearly anticipated Oliver Wendell Holmes and Semmelweis, who have received far more acclaim. Dr. Porter deserves great credit for restoring a proper perspective to the entire subject of puerperal infection.

Available data on the personal life of Alexander Gordon are scanty. The author has combed journals, records, manuscripts, registers and other contemporary sources, to piece together a biographical sketch that, even so, relies much on conjecture. The principal facts are, that Gordon was born in 1752, received an M. A. degree in 1775, studied medicine at Edinburgh and Leyden, possibly in Aberdeen, joined the Navy in 1780, as a surgeon's mate. He remained in the Navy for five years, progressing to the rank of surgeon. Retiring in 1785 on half-pay, he then studied obstetrics in London. In 1786 he settled in Aberdeen, serving as Dispensary physician. In this capacity, at an annual salary of 40 guineas, he saw an average of some 1400 patients per year, including a very considerable obstetrical practice. He also engaged in private practice. Altogether, he remained in Aberdeen until 1795, publishing in that year his *Treatise on the Epidemic Puerperal Fever of Aberdeen.* Since, however, this work actually antagonized the public, Gordon went back into the Navy. He died in 1799 of tuberculosis.

While developing the biographical details, the author throws considerable light on the medical life of the times, including the difficulties of Dispensary practice, the problems of therapy, and an account of certain unusual cases that Gordon reported. The subject of puerperal fever is excellently discussed. There is a chapter on the knowledge of the disease before 1795, presenting a background on which to depict and evaluate Gordon's own contributions.

The Scottish obstetrician had kept a very careful record of all cases that he attended, and performed a superb epidemiological analysis over several years. He recognized the connection of puerperal fever and erysipelas and knew "that they are connected, that there is an analogy between them and that they are concomitant epidemics." There was apparently the same "infectious matter." After a pregnant woman delivers, "the matter is readily and copiously admitted by the numerous patulous orifices, which are open to imbibe it, by the separation of the placenta from the uterus." The cause he recognized to be a "specific contagion or infection," and not a "noxious constitution of the atmosphere." He could trace the epidemiology, and declared, "I could venture to foretell what women would be affected with the disease, upon hearing by what midwife they were to be delivered." For prevention, he recommended that ". . . the nurses and physicians who attended patients affected with the puerperal fever, ought carefully to wash themselves and to get their apparel properly fumigated." While Gordon unfortunately concerned himself too much with methods of treatment, particularly bleeding and purging as befitted an "inflammatory disease," the essentials of etiology and prevention are nevertheless all explicitly declared.

The author, in this brief monograph, gives a sound evaluation in the field of puerperal infection. The work is an excellent example of book-making, with numerous illustrations and facsimiles. It is a welcome contribution to eighteenth century medical history.

LESTER S. KING

THE BULLETIN RECENTLY RECEIVED *

George E. Arrington, Jr. *A History of Ophthalmology.* (MD Monographs on Medical History, Number Three) New York: MD Publications, Inc., 1959. xvii + 174 pp. $4.00.

Marcel Florkin. "Épisodes de la Médecine Liégeoise. Caractère, démence et phrénologie de Théroigne de Méricourt." Reprinted from *Revue Médicale de Liège,* 1958, *13*: 701-711.

Thomas E. Keys. *Applied Medical Library Practice.* Springfield, Illinois: Charles C Thomas, 1958. xix + 495 pp. Ill. $10.75.

Jorge Le-Roy y Cassá. *Historia del Hospital San Francisco de Paula.* La Habana, 1958. xii + 553 pp. Ill.

Wu Lien-Teh. *Plague Fighter,* the Autobiography of a Modern Chinese Physician. Cambridge: W. Heffer and Sons Ltd., 1959. x + 667 pp. Ill. 30s.

Josef Löffler. *Die Störungen des geschlechtlichen Vermögens in der Literatur der autoritativen Theologie des Mittelalters.* Akademie der Wissenschaften und der Literatur in Mainz, Abhandlungen der Geistes- und Sozialwissenschaftlichen Klasse, Jahrgang 1958, Nr. 6. 88 pp. DM. 8.40.

Lelland J. Rather (translator). *Disease, Life, and Man: Selected Essays by Rudolf Virchow.* Stanford, California: Stanford University Press, 1958. vii + 273 pp. $5.00. (Stanford Studies in the Medical Sciences, IX).

Ayres L. Ribeiro. "A Study of the Antiquities in Relation to Medicine, Surgery and Gynaecology." Reprinted from *Medical Proceedings, Mediese Bydraes,* 1958, *4*: 198-208.

Walther Riese. *A History of Neurology.* (MD Monographs on Medical History, Number Two) New York: MD Publications, Inc., 1959. 223 pp. $4.00.

George Rosen. *Victor Robinson. A Romantic Medical Historian.* First Annual Victor Robinson Lecture in History of Medicine, Temple University School of Medicine, September 23, 1958. 20 pp. Ill.

* The *Bulletin* reserves freedom of decision as to the publications to be listed in this section. Items received, other than those assigned for review, are ultimately incorporated into the collection of the Institute of the History of Medicine.

CONTRIBUTORS TO THIS NUMBER

DAVID L. COWEN, M. A., is Chairman of the Department of History and Political Science, University College, Rutgers University, New Brunswick, New Jersey.

RALPH W. EDWARDS, M. A., D. D. S., is Assistant Professor of Oral Surgery and Lecturer in the History of Medicine, University of Kansas Medical Center, Kansas City 12, Kansas.

BRUNO GEBHARD, M. D., is Director of the Cleveland Health Museum, 8911 Euclid Avenue, Cleveland 6, Ohio.

GEORGIANNA SIMMONS GITTINGER, M. A., is Instructor in Pharmacology, School of Pharmacy, University of Maryland, Baltimore 1, Maryland.

EDVARD GOTFREDSEN, M. D., is Professor of the History of Medicine at the University of Copenhagen. His address is Københavns Universitets Medicinsk Historiske Museum, Bredgade 62, København K. Denmark.

CHRISTOPHER ADRIAN HOLBOROW, M. A., M. B., B. Chir., F. R. C. S., F. R. C. S. (Ed), D. L. O., is Senior Registrar, Ear Nose and Throat Department, The Hospital for Sick Children, Great Ormond Street, London, W. C. 1, England.

LESTER S. KING, M. D., is Clinical Professor of Pathology, University of Illinois College of Medicine; Pathologist, Illinois Masonic Hospital, 836 Wellington Avenue, Chicago 14, Illinois.

PAUL KLEMPERER, M. D., is Consulting Pathologist, Mount Sinai Hospital, Fifth Avenue and 100th Street, New York 29, New York.

VICTOR A. MCKUSICK, M. D., is Associate Professor of Medicine, The Johns Hopkins University, School of Medicine, Baltimore 5, Maryland.

MARK M. RAVITCH, M. D., is Associate Professor of Surgery, The Johns Hopkins University, School of Medicine, Baltimore 5, Maryland.

JAMES G. RONEY, JR., M. D., Ph. D., M. P. H., is Director, Butler County Health Department, and Lecturer, Department of Public Health Practice, Graduate School of Public Health, University of Pittsburgh. His address is 426 N. Main Street, Butler, Pennsylvania.

RUDOLPH E. SIEGEL, M. D., is in practice as internist in Buffalo, New York. He is certified by the American Board of Internal Medicine and Cardiology. His address is 458 West Delavan Avenue, Buffalo 13, New York.

JERRY STANNARD, Ph. D., is Instructor, College of the Liberal Arts, Department of Philosophy, The Penn. State University, University Park, Pennsylvania.

LYNN THORNDIKE, Ph. D., L. H. D., Litt. D., is Professor Emeritus of History, Columbia University, and resides at 4 West 43rd Street, New York 36, New York.

H. KENNETH WISKIND, B. M. E., M. S. M. E., is Instructor in Mechanical Engineering at The Johns Hopkins University, Baltimore 18, Maryland.